# CHAPTER 8. LIFE-CYCLE COST AND PAYBACK PERIOD ANALYSIS

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# CHAPTER 8. LIFE-CYCLE COST AND PAYBACK PERIOD ANALYSIS

## 8.1 INTRODUCTION

This chapter describes the Department of Energy (DOE)'s methodology for analyzing the economic impacts of possible energy efficiency standards on individual consumers. The effect of standards on individual consumers includes a change in operating expense (usually decreased) and a change in purchase price (usually increased). This chapter describes three metrics DOE used in the consumer analysis to determine the effect of standards on individual consumers:

- **Life-cycle cost** (LCC) is the total consumer expense over the life of an appliance, including purchase expense and operating costs (including energy expenditures). DOE discounts future operating costs to the time of purchase, and sums them over the lifetime of the equipment.

- **Payback period** (PBP) measures the amount of time it takes customers to recover the assumed higher purchase price of more energy-efficient equipment through lower operating costs.

- **Rebuttable payback period** is a special case of the PBP. Where LCC and PBP are estimated over a range of inputs reflecting actual conditions, rebuttable payback period is based on laboratory conditions, specifically DOE test procedure inputs.

Inputs to the LCC and PBP are discussed in sections 8.2 and 8.3, respectively, of this chapter. Results for the LCC and PBP are presented in section 8.4. The rebuttable PBP is discussed in section 8.5. Key variables and calculations are presented for each metric. DOE performed the calculations discussed here using a series of Microsoft Excel® spreadsheets which are accessible on the Internet (http://www.eere.energy.gov/buildings/appliance_standards/). Details and instructions for using the spreadsheets are discussed in Appendix 8A.

The technical support document (TSD) for DOE's notice of proposed rulemaking (NOPR) covered conventional cooking products (i.e., cooktops and ovens), microwave oven energy factor (EF), microwave oven standby power consumption, and commercial clothes washers (CCW).[1] This chapter presents information and results pertaining solely to conventional cooking products and microwave oven EF. The impact of more-efficient equipment on microwave oven standby power and CCWs will be addressed in subsequent TSDs.

### 8.1.1 General Approach for LCC and PBP Analysis

Recognizing that several inputs to the determination of consumer LCC and PBP are either variable or uncertain, DOE conducted the LCC and PBP analysis by modeling both the uncertainty and variability in the inputs using Monte Carlo simulation and probability

distributions. A detailed explanation of Monte Carlo simulation and the use of probability distributions is contained in Appendix 8B. DOE developed LCC and PBP spreadsheet models incorporating both Monte Carlo simulation and probability distributions by using Microsoft Excel® spreadsheets combined with Crystal Ball® (a commercially available add-in program).

In addition to characterizing several of the inputs to the analysis with probability distributions, DOE also developed a sample of individual households that use each of the appliances. The household sample sizes for the residential cooking products are: 2,896 for electric cooktops; 1,460 for electric standard ovens; 1,302 for electric self-cleaning ovens; 1,598 for gas cooktops; 1,082 for gas standard ovens; 373 for gas self-cleaning ovens; and 4,150 for microwave ovens. By developing household samples, DOE was able to perform the LCC and PBP calculations for each household to account for the variability in energy consumption and/or energy price associated with each household. As described in Chapter 6, DOE used the DOE Energy Information Administration (EIA)'s 2001 Residential Energy Consumption Survey (RECS) to develop household samples for each of the above three sets of products.[2] The 2001 RECS is a national sample survey of housing units that collects statistical information on the consumption of and expenditures for energy in housing units along with data on energy-related characteristics of the housing units and occupants. The 2001 RECS consists of for 4,822 housing units and was constructed by EIA to be a national representation of the household population in the U.S. Of the household sub-samples used in the LCC and PBP analysis, only two (for dehumidifiers and gas self-cleaning ovens) have a size which is less than 20 percent of the total 2001 RECS housing unit size. Even so, the potential errors associated with these smaller sub-sample sizes are not anticipated to be so large as to affect the validity of the results. Specifically, the standard error of a sample of size 'n' is the sample's standard deviation divided by the square root of 'n'. For the full 2001 RECS sample the associated standard error is the sample's standard deviation multiplied by 1.5 percent. For the gas self-cleaning oven sub-sample, the associated standard error is the sub-sample's standard deviation multiplied by 4.5 percent. Although the standard error of the sub-samples is three times the size of the entire 2001 RECS, it is still less than five percent. DOE believes a standard error of less than five percent is still small enough to yield meaningful results. Therefore, DOE believes the results generated from the household samples for cooking products are representative of U.S. households using these appliances.

DOE used RECS to establish the variability in annual energy use and energy pricing. By using RECS, DOE was able to assign a unique annual energy use and energy price to each household in the sample. Due to the large sample of households considered in the LCC and PBP analysis, the range of annual energy use and energy prices is quite large (the actual ranges of energy consumption were presented and discussed in Chapter 6). Thus, although the annual energy use and energy pricing are not uncertain for any particular household, their variability across all households contributes to the range of LCCs and PBPs calculated for any particular standard level.

DOE displays the LCC and PBP results as distributions of impacts compared to the baseline conditions. Results are presented at the end of this chapter and are based on 10,000 samples per Monte Carlo simulation run. To illustrate the implications of the analysis, DOE

generated a frequency chart depicting the variation in LCC and PBP for each standard level considered.

### 8.1.2 Overview of LCC and PBP Inputs

The LCC is the total consumer expense over the life of the equipment, including purchase expense and operating expense (including energy expenditures). DOE discounts future operating expenses to the time of purchase and sums them over the lifetime of the equipment. The PBP is the change in purchase expense due to an increased efficiency standard divided by the change in annual operating expense that results from the standard. It represents the number of years it will take the customer to recover the increased purchase expense through decreased operating expenses.

DOE categorizes inputs to the LCC and PBP analysis as follows: (1) inputs for establishing the purchase expense, otherwise known as the total installed cost, and (2) inputs for calculating the operating cost.

The primary inputs for establishing the total installed cost are:

- *Baseline manufacturer cost*: The costs incurred by the manufacturer to produce equipment meeting existing minimum efficiency standards.

- *Standard-level manufacturer cost increases*: The change in manufacturer cost associated with producing equipment to meet a particular standard level.

- *Markups and sales tax*: The markups and sales tax associated with converting the manufacturer cost to a consumer equipment price. The markups and sale tax are described in detail in Chapter 7, Markups for Equipment Price Determination.

- *Installation cost*: The cost to the consumer of installing the equipment. The installation cost represents all costs required to install the equipment other than the marked-up consumer equipment price. The installation cost includes labor, overhead, and any miscellaneous materials and parts. Thus, the total installed cost equals the consumer equipment price plus the installation cost.

The primary inputs for calculating the operating cost are:

- *Equipment energy consumption*: The equipment energy consumption is the site energy use associated with operating the equipment. Chapter 6, Energy Use Determination, details how DOE determined the equipment energy consumption based on various data sources.

- *Equipment efficiency*: The equipment efficiency dictates the equipment energy consumption associated with standard-level equipment (i.e., equipment with efficiencies

greater than baseline equipment). Chapter 6, Energy Use Determination, details how energy consumption change with increasing equipment efficiency.

- *Energy prices*: Energy prices are the prices paid by consumers for energy (i.e., electricity, gas, or oil). DOE determined current energy prices based on data from the DOE- EIA.

- *Energy price trends*: DOE used the EIA *Annual Energy Outlook 2009* (*AEO2009*) to forecast energy prices into the future. For the results presented in this chapter, DOE used the *AEO2009* reference case to forecast future energy prices.

- *Repair and maintenance costs*: Repair costs are associated with repairing or replacing components that have failed. Maintenance costs are associated with maintaining the operation of the equipment.

- *Lifetime*: The age at which the equipment is retired from service.

- *Discount rate*: The rate at which DOE discounted future expenditures to establish their present value.

Figure 8.1.1 graphically depicts the relationships between the installed cost and operating cost inputs for the calculation of the LCC and PBP. In the figure below, the yellow boxes indicate the inputs, the green boxes indicate intermediate outputs, and the blue boxes indicate the final outputs (the LCC and PBP).

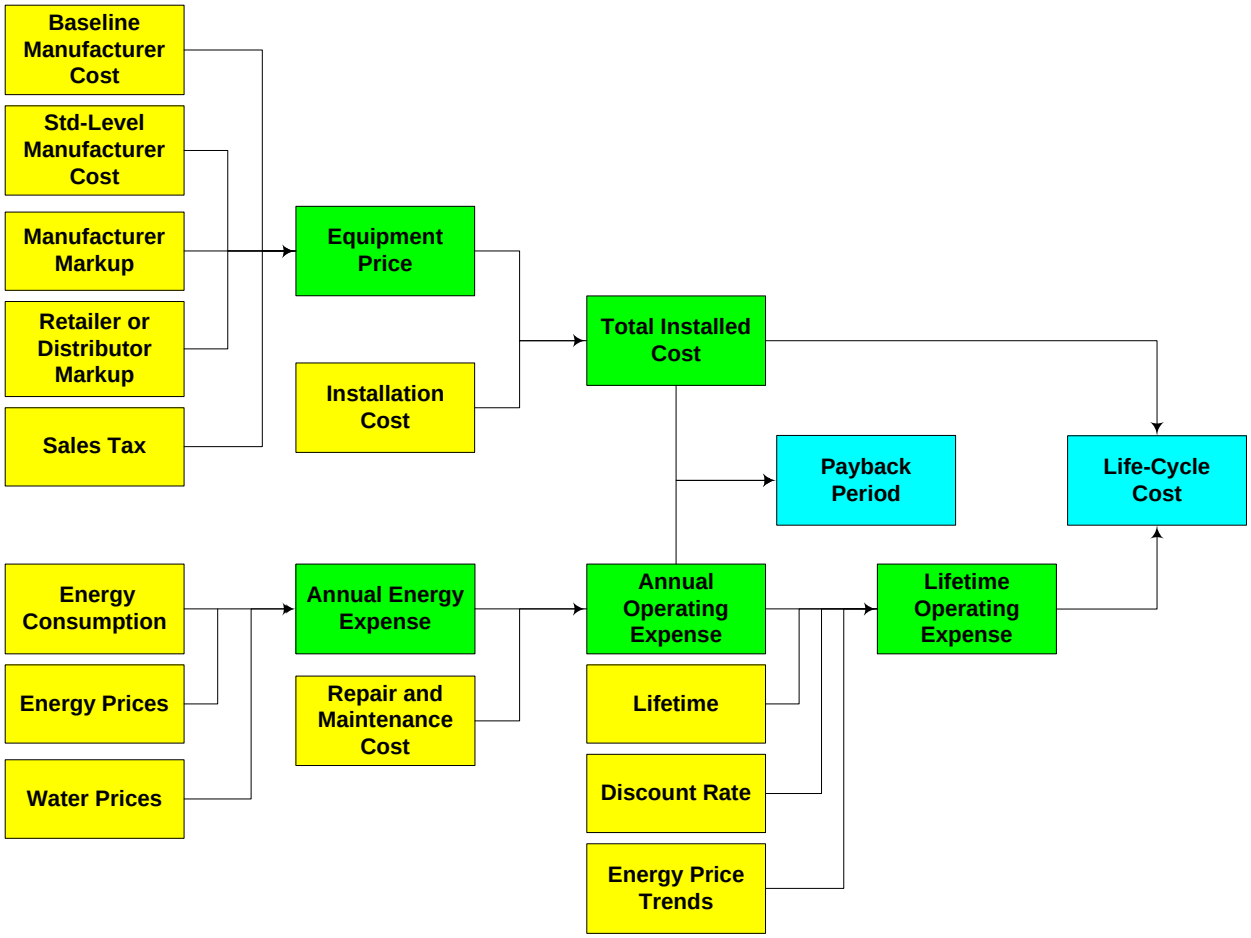


**Figure 8.1.1 Flow Diagram of Inputs for the Determination of LCC and PBP**

Tables 8.1.1 through 8.1.3 summarize the input values that DOE used to calculate the LCC and PBP for cooktops, ovens, and microwave ovens. Each table summarizes the total installed cost inputs and the operating cost inputs including the lifetime, discount rate, and energy price trends. DOE characterized all of the total cost inputs with single-point values, but characterized several of the operating cost inputs with probability distributions that capture the input's uncertainty and/or variability. For those inputs characterized with probability distributions, the values provided in the following tables are the average or typical values. Also listed in the following tables is the section of the technical support document (TSD) where more detailed information on the inputs can be found.

## Table 8.1.1 Cooktops: LCC and PBP Input Summary

| Input | Product Class | Average or Typical Value | Characterization | TSD Section Reference |
|---|---|---|---|---|
| **Total Installed Cost Inputs** | | | | |
| Baseline Manufacturer Cost | Electric Coil | 0.737 EF = $64.72 | Single-Point Value | 8.2.1.1 |
| | Electric Smooth | 0.742 EF = $83.54 | Single-Point Value | 8.2.1.1 |
| | Gas | 0.156 EF = $83.70 | Single-Point Value | 8.2.1.1 |
| Standard-Level Manufacturer Cost Increase | Electric Coil | 0.769 EF = $2.14 | Single-Point Value | 5.5.3 |
| | Electric Smooth | 0.753 EF = $155.71 | Single-Point Value | 5.5.3 |
| | Gas | 0.399 EF = $11.30<br>0.420 EF = $30.12 | Single-Point Value | 5.5.3 |
| Manufacturer Markup | All | 1.26 | Single-Point Value | 7.2 |
| Retailer Markup | All | Baseline = 1.45<br>Incremental = 1.15 | Single-Point Value | 7.3 |
| Sales Tax | Electric | 1.0677 | Single-Point Value | 7.5 |
| | Gas | 1.0713 | Single-Point Value | 7.5 |
| Installation Cost | All | Baseline = $146.06<br>Gas with electronic ignition = $118 for those households needing to install an outlet | Single-Point Value | 8.2.1.1 |
| **Operating Cost Inputs** | | | | |
| Usage | Electric | 1.22 meals/day | Variability determined from household sample. Usage ranges from 0 to 4 meals/day | 6.2.1.4 |
| | Gas | 1.29 meals/day | | 6.2.1.4 |
| Annual Energy Use | Electric | Baseline use* = 128.2 kWh | Variability based on usage | 6.2.1.3 |
| | Gas | Baseline use* = 2.74 MMBtu | Variability based on usage | 6.2.1.3 |
| Energy Prices | All | Elec = 10.5 – 11.7 ¢/kWh<br>Gas = 14.99 $/MMBtu | Variability based on region | 8.2.2.2 |
| Repair and Maintenance Costs | All | Elec: No cost increase with efficiency<br>Gas: Standing Pilot Ignition = $126 in 10$^{th}$ year;<br>Electronic Ignition = $178 in 10$^{th}$ year | Single-Point Value | 8.2.2.4 |
| Lifetime | Electric | 19.0 years | Weibull distribution = 10 to 28 years | 8.2.3.1 |
| | Gas | 19.0 years | Weibull distribution = 12 to 26 years | 8.2.3.1 |
| Discount Rate | All | 5.4% | Custom distribution | 8.2.4 |
| Energy Price Trend | All | AEO 2009 Early Release Reference Case | Two sensitivities:<br>AEO 2008 High & Low Growth Cases | 8.2.2.3 |

* Annual use provided for baseline product only. Annual consumption decreases with increased product efficiency.

## Table 8.1.2 Ovens: LCC and PBP Input Summary

| Input | Product Class | Average or Typical Value | Characterization | TSD Section Reference |
|---|---|---|---|---|
| **Total Installed Cost Inputs** | | | | |
| Baseline Manufacturer Cost | Elec Standard | 0.1066 EF = $137.12 | Single-Point Value | 8.2.1.2 |
| | Elec Self-Clean | 0.1099 EF = $173.69 | Single-Point Value | 8.2.1.2 |
| | Gas Standard | 0.0298 EF = $145.43 | Single-Point Value | 8.2.1.2 |
| | Gas Self-Clean | 0.0540 EF = $206.93 | Single-Point Value | 8.2.1.2 |
| Standard-Level Manufacturer Cost Increase | Elec Standard | 0.1113 EF = $1.53<br>0.1163 EF = $4.54<br>0.1181 EF = $8.01<br>0.1206 EF = $45.16<br>0.1209 EF = $48.49 | Single-Point Value | 5.5.3 |
| | Elec Self-Clean | 0.1102 EF = $4.10<br>0.1123 EF = $41.26 | Single-Point Value | 5.5.3 |
| | Gas Standard | 0.0536 EF = $11.33<br>0.0566 EF = $14.69<br>0.0572 EF = $15.71<br>0.0593 EF = $36.51<br>0.0596 EF = $38.03<br>0.0600 EF = $41.44<br>0.0583 EF = $14.09 | Single-Point Value | 5.5.3 |
| | Gas Self-Clean | 0.0625 EF = $10.34<br>0.0627 EF = $14.45<br>0.0632 EF = $15.60 | Single-Point Value | 5.5.3 |
| Manufacturer Markup | All | 1.26 | Single-Point Value | 7.2 |
| Retailer Markup | All | Baseline = 1.45<br>Incremental = 1.15 | Single-Point Value | 7.3 |
| Sales Tax | Elec Standard | 1.0681 | Single-Point Value | 7.5 |
| | Elec Self-Clean | 1.0671 | Single-Point Value | 7.5 |
| | Gas Standard | 1.0714 | Single-Point Value | 7.5 |
| | Gas Self-Clean | 1.0706 | Single-Point Value | 7.5 |
| Installation Cost | All | Baseline = $146.06<br>Gas with electronic or glo-bar ignition = $118 for those households needing to install an outlet | Single-Point Value | 8.2.1.2 |
| **Operating Cost Inputs** | | | | |
| Usage | Elec Standard | 0.52 meals/day | Variability determined from household sample. Usage ranges from 0 to 2 meals/day | 6.2.1.4 |
| | Elec Self-Clean | 0.57 meals/day | | 6.2.1.4 |
| | Gas Standard | 0.49 meals/day | | 6.2.1.4 |
| | Gas Self-Clean | 0.56 meals/day | | 6.2.1.4 |
| Annual Energy Use | Elec Standard | Baseline use* = 166.5 kWh | Variability based on usage | 6.2.1.3 |
| | Elec Self-Clean | Baseline use* = 171.0 kWh | Variability based on usage | 6.2.1.3 |
| | Gas Standard | Baseline use* = 1.83 MMBtu | Variability based on usage | 6.2.1.3 |

| Input | Product Class | Average or Typical Value | Characterization | TSD Section Reference |
|---|---|---|---|---|
| | Gas Self-Clean | Baseline use* = 0.86 MMBtu<br>= 53.3 kWh | Variability based on usage | 6.2.1.3 |
| Energy Prices | All | Elec = 10.4 – 11.7 ¢/kWh<br>Gas = 15.00 – 15.03 $/MMBtu | Variability based on region | 8.2.2.2 |
| Repair and Maintenance Costs | All | Elec: No cost increase with efficiency<br>Gas: Standing Pilot Ignition = $126 in 10th year;<br>Electronic Ignition = $178 in 10th year;<br>Glo-bar Ignition = $147 every 5th year | No cost increase with efficiency | 8.2.2.4 |
| Lifetime | Electric | 19.0 years | Weibull distribution =<br>10 to 28 years | 8.2.3.1 |
| | Gas | 19.0 years | Weibull distribution =<br>12 to 26 years | 8.2.3.1 |
| Discount Rate | All | 5.4% - 5.5% | Custom distribution | 8.2.4 |
| Energy Price Trend | All | AEO 2009 Early Release Reference Case | Two sensitivities:<br>AEO 2008 High & Low Growth Cases | 8.2.2.3 |

* Annual use provided for baseline product only. Annual use decreases with increased product efficiency.

**Table 8.1.3 Microwave Ovens: LCC and PBP Input Summary**

| Input | Average or Typical Value | Characterization | TSD Section Reference |
|---|---|---|---|
| **Total Installed Cost Inputs** | | | |
| Baseline Manufacturer Cost | 0.557 EF = $112.57 | Single-Point Value | 8.2.1.3 |
| Standard-Level Manufacturer Cost Increase | 0.586 EF = $8.14<br>0.588 EF = $16.84<br>0.597 EF = $30.52<br>0.602 EF = $47.95 | Single-Point Value | 5.5.3 |
| Manufacturer Markup | 1.26 | Single-Point Value | 7.2 |
| Retailer Markup | Baseline = 1.45<br>Incremental = 1.15 | Single-Point Value | 7.3 |
| Sales Tax | 1.0689 | Single-Point Value | 7.5 |
| Installation Cost | $0 | Single-Point Value | 8.2.1.3 |
| **Operating Cost Inputs** | | | |
| Usage | 0.40 meals/day | Variability determined from household sample. Usage ranges from 0 to 4 meals/day | 6.2.2.4 |
| Annual Energy Use* | Baseline use* = 165.8 kWh | Variability based on usage | 6.2.2.3 |
| Energy Prices | 10.8 ¢/kWh | Variability based on region | 8.2.2.2 |
| Repair and Maintenance Costs | No cost increase with efficiency | No cost increase with efficiency | 8.2.2.4 |
| Lifetime | 9.0 years | Weibull distribution =<br>7 to 10 years | 8.2.3.2 |
| Discount Rate | 5.4% | Custom distribution | 8.2.4 |
| Energy Price Trend | AEO 2009 Early Release Reference Case | Two sensitivities:<br>AEO 2008 High & Low Growth Cases | 8.2.2.3 |

* Annual use provided for baseline product only. Annual use decreases with increased product efficiency.

## 8.2 LIFE-CYCLE COST INPUTS

Life-cycle cost is the total customer expense over the life of an appliance, including purchase expense and operating costs (including energy expenditures). DOE discounts future operating costs to the time of purchase, and sums them over the lifetime of the equipment. DOE defines LCC by the following equation:

$$LCC = IC + \sum_{t=1}^{N} \frac{OC_t}{(1+r)^t}$$

where:

*LCC* = Life-cycle cost in dollars,
*IC* = Total installed cost in dollars,
∑ = Sum over the lifetime, from year 1 to year N,
N = Lifetime of appliance in years,
*OC* = Operating cost in dollars,
*r* = Discount rate, and
*t* = Year for which operating cost is being determined.

Because DOE gathered most of its data for the LCC and PBP analysis in 2006, DOE expresses dollar values in 2006$.

The following sections discuss total installed cost, operating cost, lifetime, and discount rate.

### 8.2.1 Total Installed Cost Inputs

DOE defines the total installed cost using the following equation:

$$\boldsymbol{IC = EQP + INST}$$

where:

*EQP* = Equipment price (i.e., customer price for the equipment only), expressed in dollars, and
*INST* = Installation cost or the customer price to install equipment (i.e., the cost for labor and materials), also in dollars.

The equipment price is based on how the consumer purchases the equipment. As discussed in Chapter 7, Markups for Equipment Price Determination, DOE defined markups and sales taxes for converting manufacturing costs into consumer equipment prices.

Table 8.2.1 summarizes the inputs for the determination of total installed cost.

**Table 8.2.1 Inputs for Total Installed Cost**

| |
|---|
| Baseline Manufacturer Cost |
| Standard-Level Manufacturer Cost |
| Manufacturer Markup |
| Retailer or Distributor Markup |
| Sales Tax |
| Installation Cost |

The *baseline manufacturer cost* is the cost incurred by the manufacturer to produce equipment meeting existing minimum efficiency standards. *Standard-level manufacturer cost increases* are the change in manufacturer cost associated with producing equipment at a standard level. *Markups and sales tax* convert the manufacturer cost to a consumer equipment price. The *installation cost* is the cost to the consumer of installing the equipment and represents all costs required to install the equipment other than the marked-up consumer equipment price. The installation cost includes labor, overhead, and any miscellaneous materials and parts. Thus, the total installed cost equals the consumer equipment price plus the installation cost. DOE calculated the total installed cost for baseline products based on the following equation:

$$\begin{aligned} IC_{BASE} &= EQP_{BASE} + INST_{BASE} \\ &= COST_{MFG} \times MU_{OVERALL\_BASE} + INST_{BASE} \end{aligned}$$

where:

$IC_{BASE}$ = Baseline total installed cost,
$EQP_{BASE}$ = Consumer equipment price for baseline models,
$INST_{BASE}$ = Baseline installation cost,
$COST_{MFG}$ = Manufacturer cost for baseline models, and
$MU_{OVERALL\_BASE}$ = Baseline overall markup (product of manufacturer markup, baseline retailer or distributor markup, and sales tax).

DOE calculated the total installed cost for standard-level products based on the following equation:

$$\begin{aligned} IC_{STD} &= EQP_{STD} + INST_{STD} \\ &= \left(EQP_{BASE} + \Delta EQP_{STD}\right) + \left(INST_{BASE} + \Delta INST_{STD}\right) \\ &= \left(EQP_{BASE} + INST_{BASE}\right) + \left(\Delta EQP_{STD} + \Delta INST_{STD}\right) \\ &= IC_{BASE} + \left(\Delta COST_{MFG} \times MU_{OVERALL\_INCR} + \Delta INST_{STD}\right) \end{aligned}$$

where:

$IC_{STD}$ = Standard-level total installed cost,
$EQP_{STD}$ = Consumer equipment price for standard-level models,
$INST_{STD}$ = Standard-level installation cost,
$EQP_{BASE}$ = Consumer equipment price for baseline models,
$\Delta EQP_{STD}$ = Change in equipment price for standard-level models,
$INST_{BASE}$ = Baseline installation cost,
$\Delta INST_{STD}$ = Change in installation cost for standard-level models,
$IC_{BASE}$ = Baseline total installed cost,
$\Delta COST_{MFG}$ = Change in manufacturer cost for standard-level models, and
$MU_{OVERALL\_INCR}$ = Incremental overall markup (product of manufacturer markup, incremental retailer or distributor markup, and sales tax).

The remainder of this section provides information about each of the above input variables that DOE used to calculate the total installed cost for cooking products.

#### 8.2.1.1 Cooktops

***Baseline Manufacturer Cost***

DOE used its 1996 *Technical Support Document for Residential Cooking Products* to develop the baseline manufacturer costs for cooktops.[3] As shown in Table 8.2.2, DOE developed baseline manufacturer costs for the three cooktop product classes: electric coil, electric smooth, and gas. Also included in Table 8.2.2 are the associated baseline energy factors and cooking efficiencies.

**Table 8.2.2 Cooktops: Baseline Manufacturer Costs**

| Product Class | Baseline Energy Factor | Baseline Cooking Efficiency | Baseline Manufacturer Cost | |
|---|---|---|---|---|
| | | | (1990$)* | (2006$) |
| Electric, Coil | 0.737 | 73.7% | $69.06 | $64.72 |
| Electric, Smooth | 0.742 | 74.2% | $89.14 | $83.54 |
| Gas | 0.156 | 39.9% | $89.09 | $83.70 |

* **Source:** U.S. DOE, *Technical Support Document for Residential Cooking Products*, 1996.

The manufacturer cost data reported in DOE's 1996 *Technical Support Document for Residential Cooking Products* are in 1990$. Because DOE conducted the LCC and PBP analysis in 2006$, it needs to convert all cost data into 2006$. The last column in Table 8.2.2 shows the baseline manufacturer costs in 2006$. To perform the necessary monetary conversion for cooking products, DOE used producer price indexes (PPIs) for household cooking appliance manufacturers.[4] The PPI is a family of indexes that measure changes in price for inputs into production processes, such as labor, raw materials, and purchased parts. Because the PPI measures the price change from the perspective of the manufacturer, DOE used the PPI to convert the manufacturer price (the manufacturer costs multiplied by the manufacturer markup) from 1990$ into 2006$. Specifically, DOE determined the ratio of the 2006 PPI to the 1990 PPI

and used it as a multiplicative factor to convert the manufacturer price into 2006$. Table 8.2.3 shows the 1990 and 2006 PPIs for electric and gas cooking appliance manufacturers. Included in the table is the ratio of the two PPI values.

**Table 8.2.3 Cooking Products: Producer Price Indexes**

| | **Industry: Household cooking appliance manufacturers** | |
|---|---|---|
| **Year** | **Product:** Electric and microwave household cooking units and parts **Series Id:** PCU3352213352211 | **Product:** Gas household units and related parts and accessories **Series Id:** PCU3352213352213 |
| 1990 | 101.8 | 119.0 |
| 2006 | 95.5 | 111.8 |
| Ratio | 0.938 | 0.939 |

**Source:** U.S. Department of Labor, Bureau of Labor Statistics, Household Cooking Appliance Manufacturers, 2006.

***Standard-Level Manufacturer Cost Increases***

DOE used its 1996 *Technical Support Document for Residential Cooking Products* to develop manufacturer cost increases associated with increases in product standard levels. Refer to Chapter 5, Engineering Analysis, for details. Tables 8.2.4, 8.2,5, and 8.2.6 summarize the standard-level manufacturer cost increases for electric coil, electric smooth, and gas cooktops, respectively. Also included in each of the tables are the associated baseline energy factors and cooking efficiencies.

**Table 8.2.4 Electric Coil Cooktops: Standard-Level Manufacturer Cost Increases**

| **Standard Level** | **Energy Factor** | **Cooking Efficiency** | **Standard-Level Manufacturer Cost Increase (2006$)** |
|---|---|---|---|
| Baseline | 0.737 | 73.7% | - |
| 1 | 0.769 | 76.9% | $2.14 |

**Table 8.2.5 Electric Smooth Cooktops: Standard-Level Manufacturer Cost Increases**

| **Standard Level** | **Energy Factor** | **Cooking Efficiency** | **Standard-Level Manufacturer Cost Increase (2006$)** |
|---|---|---|---|
| Baseline | 0.742 | 74.2% | - |
| 1 | 0.753 | 75.3% | $155.71 |

**Table 8.2.6 Gas Cooktops: Standard-Level Manufacturer Cost Increases**

| **Standard Level** | **Energy Factor** | **Cooking Efficiency** | **Standard-Level Manufacturer Cost Increase (2006$)** |
|---|---|---|---|
| Baseline | 0.156 | 39.9% | - |
| 1 | 0.399 | 39.9% | $11.33 |
| 2 | 0.420 | 42.0% | $30.12 |

### *Overall Markup*

The overall markup is the value determined by multiplying the manufacturer and retailer markups and the sales tax together to arrive at a single markup value. In turn, DOE multiplied the overall markup by the baseline or standard-level manufacturer cost to arrive at the price paid by the consumer for the product. DOE divided the overall markup into a baseline markup (i.e., a markup used to convert the baseline manufacturer cost into a consumer price) and an incremental markup (i.e., a markup used to convert an incremental manufacturer cost due to a standard level into an incremental consumer price). Table 8.2.7 shows the overall markups for electric and gas cooktops. Refer to Chapter 7, Markups for Equipment Price Determination, for details.

**Table 8.2.7 Cooktops: Overall Markups**

| | **Electric Coil and Smooth Cooktops** | | **Gas Cooktops** | |
|---|---|---|---|---|
| **Markup** | Baseline | Incremental | Baseline | Incremental |
| Manufacturer | 1.26 | | 1.26 | |
| Retailer | 1.45 | 1.15 | 1.45 | 1.15 |
| Sales Tax | 1.0677 | | 1.0713 | |
| **Overall** | 1.95 | 1.55 | 1.96 | 1.55 |

### *Installation Cost*

DOE derived baseline installation costs for cooktops from data in the *RS Means Mechanical Cost Data, 2005*.[5] This reference provides estimates on the labor required to install residential cooking range equipment. Table 8.2.8 summarizes the nationally representative costs associated with the installation of a 30-inch, free-standing cooking range as presented in *RS Means Mechanical Cost Data*. DOE decided that the costs of installing a range are representative of the costs of installing a cooktop. Table 8.2.21 provides both bare costs (i.e., costs before overhead and profit (O&P)) and installation costs including O&P. *RS Means* provides minimum and maximum costs. DOE used the average of the minimum and maximum labor costs as its estimate of installation costs for cooktops. DOE used the Consumer Price Index (CPI) to convert the costs from 2008$ to 2006$.[6]

**Table 8.2.8 Cooking Range: Baseline Installation Costs**

| | **Bare Costs (2008$)** | | | **Including Overhead & Profit (2008$)** | | |
|---|---|---|---|---|---|---|
| **Installation Type** | **Material** | **Labor** | **Total** | **Total** | **Material*** | **Labor**** |
| Minimum | $270 | $48.50 | $318.50 | $375 | $240.50 | $78.00 |
| Maximum | $1775 | $121 | $1896 | $2175 | $1673.50 | $222.50 |
| | | | | | **Average (2008$)** | **$150.25** |
| | | | | | **Average (2006$)***** | **$146.06** |

* Material costs including O&P equal bare costs plus 10% profit.

** DOE derived labor costs including O&P by subtracting material with O&P from total with O&P.

*** Converted to 2006$ by multiplying costs in 2008$ by the ratio of 2006 CPI (201.6) to 2007 CPI (207.3). Used the 2007 CPI due to the unavailability of an annual 2008 CPI value.

**Source:** RS Means, *Mechanical Cost Data, 2008.*

Based on a supplemental analysis to the 1996 *Technical Support Document on Residential Cooking Products*. DOE determined that only gas cooktops with electronic ignition devices would incur added installation costs. DOE conducted an assessment of the National Electric Code (NEC) to determine the percent of households with gas cooktops that would require an electrical outlet.[7]

Starting in 1933, the NEC recommended, but did not require, an outlet installation every 15 linear feet. The 1935 NEC required that one outlet be installed in each room. Subsequent versions of the NEC became more stringent in its outlet installation requirements. The 1940 NEC required that each room have an outlet installed every 20 linear feet (as measured horizontally along the wall at the floor line). The 1956 NEC tightened this requirement to 12 linear feet. Finally, the 1959 NEC required that the outlets installed in a room result in no point in any wall space be more than six feet from a receptacle outlet. To determine how to apply the information from the NEC, DOE reviewed the gas cooktop household sample that was developed for the LCC and PBP analysis to establish which households may require an outlet installation. As reported earlier in section 8.1.1, DOE's household sample was derived from the 2001 RECS and consisted of 1,598 records for gas cooktops. Because RECS specifies the household's vintage or year made, DOE was able to determine the composition of the household sample by particular vintage groupings. For gas cooktops, DOE determined that almost 26 percent of the sample consisted of households that were built before 1940, almost 28 percent fell in the 1940-1959 age group, and the remaining 46 percent were built in 1960 or later. DOE also determined that every household in each sample had an electric refrigerator. Therefore, DOE concluded that every household had at least one electrical outlet in the kitchen. But because prior to 1959 the NEC did not require outlets to be spaced every six feet, DOE assumed that households prior to 1960, representing 54 percent of the gas cooktop sample, may need an additional outlet installed in the kitchen to accommodate a gas cooking product that would need electricity to operate.

To determine the percentage of households that may actually require an outlet installation, DOE utilized the base case efficiency distribution for gas cooktops. As will be discussed in greater detail in section 8.2.6, the base case efficiency distribution identifies the percentage of shipments at certain efficiency levels. For gas cooktops, DOE estimated that 6.8 percent of shipments in 2005 were equipped with standing pilot ignition systems. Obviously, only those households that purchase gas cooking products with standing pilots would possibly be forced into installing an electrical outlet to accommodate products that require electricity to operate. DOE was not able to identify any information to specify the reasons why consumers purchase gas cooktops with standing pilots. For example, it is unknown if consumers only purchase gas cooking products with standing pilots because an electrical outlet is not nearby. Therefore, for purposes of conducting the LCC and PBP analysis, DOE allocated shipments of gas cooking products with standing pilots to all households irrespective of the possible need to install an electrical outlet. DOE allocated these shipments assuming that the percentage of the housing stock purchasing gas cooktops with pilots is equal to the percentage of products still being shipped with standing pilots. Because 54 percent of the gas cooktop household sample is comprised of households built prior to 1960, these households are slightly more likely to be allocated a product with a standing pilot. Because DOE could not conclusively determine

whether pre-1960 households would absolutely require the installation of an outlet, DOE assumed that an outlet would need to be installed to accommodate a gas cooking product that would require electricity to operate. Based on the above percentages of shipments with standing pilots and households built prior to 1960, DOE calculated that 3.7 percent of the overall gas cooktop household sample (54 percent of households multiplied by 6.8 percent of shipments) would need to install an electrical outlet to accommodate a gas cooktop that requires electricity to operate.

DOE based the type of electrical outlet and the cost of installing it on the requirements of the NEC. As noted above, DOE estimated that only pre-1960 households would need to install an electrical outlet to accommodate a gas cooking product that needs electricity to operate. Based on the NEC, not until 1962 were branch electrical circuits required to include a grounding conductor or ground path to which the grounding contacts of the receptacle could be connected. Therefore, because a ground-fault circuit-interrupter (GFCI) outlet may need to be installed, DOE based its installation costs solely on the installation of a GFCI outlet in a finished space. DOE derived its estimates based on the grounding of the outlet to a water pipe in the kitchen rather than back to a fuse box or circuit breaker panel. DOE estimated the costs based on the installation of the following components: (1) a 15-amp GFCI receptacle with 20 feet of electrical metallic tubing; (2) 25 feet of copper wire for grounding; and (3) a bronze clamp for a half-inch diameter water price for grounding. DOE relied on data from the *RS Means Mechanical Cost Data* to estimate the installation cost. Table 8.2.9 provides both the bare costs and the total costs including O&P for the installation of a 15-amp GFCI receptacle. Also included in Table 8.2.9 are the costs associated with installing the clamp and wire necessary for grounding, which were based on the 2003 version of the *RS Means Mechanical Cost Data*.[8] DOE used the CPI to convert the costs from 2008$ and 2003$ to 2006$. Because the *RS Means Mechanical Cost Data* covers large projects totaling at least $10,000, DOE added an electrician's trip charge of $21 to the installation cost.[9] The resulting installation cost determined by DOE to install an electrical outlet is $235.

**Table 8.2.9 Installation Cost for an Electrical Outlet**

| Indiv. Line # | Description | Crew | Daily Output | Person-Hours | Unit | Mat. | Labor | Equip. | Total | Total incl. O&P |
|---|---|---|---|---|---|---|---|---|---|---|
| **2008 Mechanical Cost Data: 2008 Base Costs** | | | | | | | | | | |
| 4380 | GFI, 15 amp recpt., EMT & wire | 1 Elect | 4.71 | 1.699 | Ea. | $60.50 | $77.50 | $0 | $138 | $182 |
| | | | | | | | | | Average (2006$)* | $182 |
| **2003 Mechanical Cost Data: 2003 Bare Costs** | | | | | | | | | | |
| 4020 | Clamp, bronze, ½" diameter | 1 Elect | 32 | 0.25 | Ea. | $3.81 | $9.40 | $0 | $13.21 | $18.25 |
| | | | | | | | | | Average (2006$)** | $21.75 |
| 4030 | Bare copper wire, #14 solid | 1 Elect | 14 | 0.571 | C.L.F. | $2.75 | $21.50 | $0 | $24.25 | $35.00 |
| | | | | | | | | | Average (2006$)** | $10.52 |
| Residential Electrician Trip Charge (2006$) | | | | | | | | | | $20.84 |
| **Total Installation Cost (2006$)** | | | | | | | | | | **$235.12** |

* Cost in 2008$ assumed to be representative of 2006$.

** Converted to 2006$ by multiplying costs in 2003$ by the ratio of 2006 CPI (201.6) to 2003 CPI (184.0). Bare copper wire costs reduced by 75% to account for installation of 25 feet of wire.

**Sources:** Bare Costs: RS Means, *Mechanical Cost Data, 2008 and 2003.* Trip Charge: PAS Publications, 2008.

As will be discussed later in section 8.2.6, the only gas cooktops that are still shipped with standing pilots are those in gas ranges (comprised of a cooktop and standard oven). Therefore, the cost of any outlet installation is effectively shared between the cooktop and the oven. Thus, the resulting cost for a gas cooktop consumer needing to install an electrical outlet is ½ of $235 or $118.

As discussed above, DOE estimated that 54 percent value of all households with gas cooktops need to install an electrical outlet to accommodate a gas cooktop that needs electricity to operate. As a result, the *average* installation cost for households still purchasing gas cooktops with standing pilots is 54 percent of $118 or $63.

### *Total Installed Cost*

The total installed cost is the sum of the consumer equipment price and the installation cost. Refer back to section 8.2.1 to see the equations DOE used to calculate the total installed cost for baseline and standard-level products.

Tables 8.2.10, 8.2.11, and 8.2.12 present the consumer equipment prices, installation costs, and total installed costs for the electric coil, electric smooth, and gas cooktop product classes, respectively. Prices and costs are presented at the baseline level and each standard level.

**Table 8.2.10 Electric Coil Cooktops: Consumer Equipment Prices, Installation Costs, and Total Installed Costs**

| Standard Level | Energy Factor | Equipment Price (2006$) | Installation Cost (2006$) | Total Installed Cost (2006$) |
|---|---|---|---|---|
| Baseline | 0.737 | $126.37 | $146.06 | $272.43 |
| 1 | 0.769 | $129.68 | $146.06 | $275.74 |

**Table 8.2.11 Electric Smooth Cooktops: Consumer Equipment Prices, Installation Costs, and Total Installed Costs**

| Standard Level | Energy Factor | Equipment Price (2006$) | Installation Cost (2006$) | Total Installed Cost (2006$) |
|---|---|---|---|---|
| Baseline | 0.742 | $163.12 | $146.06 | $309.18 |
| 1 | 0.753 | $404.01 | $146.06 | $550.07 |

**Table 8.2.12 Gas Cooktops: Consumer Equipment Prices, Installation Costs, and Total Installed Costs**

| Standard Level | Energy Factor | Equipment Price (2006$) | Installation Cost (2006$) | Total Installed Cost (2006$) |
|---|---|---|---|---|
| Baseline | 0.156 | $163.82 | $146.06 | $309.88 |
| 1 | 0.399 | $181.41 | $209.15* | $390.56 |
| 2 | 0.420 | $210.57 | $209.15* | $419.72 |

* Added installation cost of $63 is the average cost to gas cooktop consumers that still purchase products with standing pilots.

#### 8.2.1.2 Ovens

***Baseline Manufacturer Cost***

DOE used its 1996 *Technical Support Document for Residential Cooking Products* to develop the baseline manufacturer costs for ovens.[3] As shown in Table 8.2.13, DOE developed baseline manufacturer costs for the four oven product classes: electric standard (non-self-cleaning), electric self-cleaning, gas standard, and gas self-cleaning. Also included in Table 8.2.13 are the associated baseline energy factors and cooking efficiencies.

**Table 8.2.13 Ovens: Baseline Manufacturer Costs**

| Product Class | Baseline Energy Factor | Baseline Cooking Efficiency | Baseline Manufacturer Cost | |
|---|---|---|---|---|
| | | | (1990$)* | (2006$) |
| Electric, Standard | 0.1066 | 12.2% | $146.17 | $137.12 |
| Electric, Self-Cleaning | 0.1099 | 13.8% | $185.15 | $173.69 |
| Gas, Standard | 0.0298 | 5.9% | $154.80 | $145.43 |
| Gas, Self-Cleaning | 0.0540 | 7.1% | $220.26 | $206.93 |

***Source:** U.S. DOE, *Technical Support Document for Residential Cooking Products*, 1996.

The manufacturer cost data reported in DOE's 1996 *Technical Support Document for Residential Cooking Products* are in 1990$. Because DOE conducted the LCC and PBP analysis in 2006$, it needs to convert all cost data into 2006$. The last column in Table 8.2.13 shows the baseline manufacturer costs in 2006$. To perform the necessary monetary conversion for cooking products, DOE used PPIs for household cooking appliance manufacturers.[4] Refer back to Table 8.2.3 to review the PPIs that DOE used to perform the conversions.

***Standard-Level Manufacturer Cost Increases***

DOE developed manufacturer cost increases associated with increases in product standard levels through the use of its 1996 *Technical Support Document for Residential Cooking Products*. Refer to Chapter 5, Engineering Analysis, for details. Tables 8.2.14 through 8.2.17 summarize the standard-level manufacturer cost increases for electric standard, electric self-cleaning, gas standard, and gas self-cleaning ovens, respectively. Also included in each of the tables are the associated baseline energy factors and cooking efficiencies.

**Table 8.2.14 Electric Standard Ovens: Standard-Level Manufacturer Cost Increases**

| Standard Level | Energy Factor | Cooking Efficiency | Standard-Level Manufacturer Cost Increase (2006$) |
|---|---|---|---|
| Baseline | 0.1066 | 12.2% | - |
| 1 | 0.1113 | 12.8% | $1.53 |
| 2 | 0.1163 | 13.4% | $4.54 |
| 3 | 0.1181 | 13.7% | $8.00 |
| 4 | 0.1206 | 14.0% | $45.16 |
| 5 | 0.1209 | 14.1% | $48.49 |

**Table 8.2.15 Electric Self-Cleaning Ovens: Standard-Level Manufacturer Cost Increases**

| Standard Level | Energy Factor | Cooking Efficiency | Standard-Level Manufacturer Cost Increase (2006$) |
|---|---|---|---|
| Baseline | 0.1099 | 13.8% | - |
| 1 | 0.1102 | 13.8% | $4.10 |
| 2 | 0.1123 | 14.2% | $41.26 |

**Table 8.2.16 Gas Standard Ovens: Standard-Level Manufacturer Cost Increases**

| Standard Level | Energy Factor | Cooking Efficiency | Standard-Level Manufacturer Cost Increase (2006$) |
|---|---|---|---|
| Baseline | 0.0298 | 5.9% | - |
| 1* | 0.0536 | 5.8% | $11.33 |
| 2 | 0.0566 | 6.1% | $14.69 |
| 3 | 0.0572 | 6.2% | $15.71 |
| 4 | 0.0593 | 6.5% | $36.51 |
| 5 | 0.0596 | 6.5% | $38.03 |
| 6 | 0.0600 | 6.6% | $41.44 |
| 1a* | 0.0583 | 5.8% | $14.09 |

***** Levels 1 and 1a correspond to designs that are utilized for the same purpose—eliminate the need for a standing pilot—but the technologies for each design are different. Level 1 is a hot surface ignition device while level 1a is a spark ignition device.

**Table 8.2.17 Gas Self-Cleaning Ovens: Standard-Level Manufacturer Cost Increases**

| Standard Level | Energy Factor | Cooking Efficiency | Standard-Level Manufacturer Cost Increase (2006$) |
|---|---|---|---|
| Baseline | 0.0540 | 7.1% | - |
| 1 | 0.0625 | 8.8% | $10.34 |
| 2 | 0.0627 | 8.8% | $14.45 |
| 3 | 0.0632 | 8.9% | $15.60 |

***Overall Markup***

As described earlier for cooktops, the overall markup is the value determined by multiplying the manufacturer and retailer markups and the sales tax together to arrive at a single markup value. Table 8.2.18 shows the overall baseline and incremental markups for electric and gas ovens. Refer to Chapter 7, Markups for Equipment Price Determination, for details.

**Table 8.2.18 Ovens: Overall Markups**

| | Electric Ovens | | | | Gas Ovens | | | |
|---|---|---|---|---|---|---|---|---|
| | Standard | | Self-Clean | | Standard | | Self-Clean | |
| **Markup** | Baseline | Incr. | Baseline | Incr. | Baseline | Incr. | Baseline | Incr. |
| Manufacturer | 1.26 | | 1.26 | | 1.26 | | 1.26 | |
| Retailer | 1.45 | 1.15 | 1.45 | 1.15 | 1.45 | 1.15 | 1.45 | 1.15 |
| Sales Tax | 1.0681 | | 1.0671 | | 1.0714 | | 1.0706 | |
| **Overall** | 1.95 | 1.55 | 1.95 | 1.55 | 1.96 | 1.55 | 1.96 | 1.55 |

***Installation Cost***

Using the same methodology and data as described earlier for cooktops, DOE derived baseline installation costs for ovens based on data in the *RS Means Mechanical Cost Data, 2008*.

Refer back to Table 8.2.8 to review the installation costs DOE used for cooking ranges. DOE used the cooking range installation cost data to estimate its installation costs for ovens.

As it did for cooktops, DOE based its installation costs for oven standard levels on a supplemental analysis to the 1996 *Technical Support Document on Residential Cooking Products*. In the supplemental analysis, DOE determined that only gas standard ovens with electric or electronic ignition devices would incur added installation costs. DOE used the same methodology and data as described earlier for gas cooktops to estimate the increased installation costs for gas standard ovens.

As discussed previous in section 8.2.1.2 for gas cooktops, DOE used the information from the NEC to determine which gas cooktop households may require the installation of an electrical outlet. DOE applied this same NEC information to the gas standard oven household sample that was developed for the LCC and PBP analysis to establish which households may require an outlet installation. As reported earlier in section 8.1.1, DOE's household sample was derived from the 2001 RECS and consisted of 1,082 records for gas standard ovens. Because RECS specifies the household's vintage or year made, DOE was able to determine the composition of the household sample by particular vintage groupings. For gas standard ovens, DOE determined that almost 28 percent of the sample consisted of households that were built before 1940, almost 29 percent fell in the 1940-1959 age group, and the remaining 43 percent were built in 1960 or later. DOE also determined that every household in each sample had an electric refrigerator. Therefore, DOE concluded that every household had at least one electrical outlet in the kitchen. But because prior to 1959 the NEC did not require outlets to be spaced every six feet, DOE assumed that households prior to 1960, representing 57 percent of the gas cooktop sample, may need an additional outlet installed in the kitchen to accommodate a gas cooking product that would need electricity to operate.

To determine the percentage of households that may actually require an outlet installation, DOE utilized the base case efficiency distribution for gas standard ovens. As will be discussed in greater detail in section 8.2.6, the base case efficiency distribution identifies the percentage of shipments at certain efficiency levels. For gas standard ovens, DOE estimated that 17.6 percent of shipments in 2005 were equipped with standing pilot ignition systems. Obviously, only those households that purchase gas cooking products with standing pilots would possibly be forced into installing an electrical outlet to accommodate products that require electricity to operate. DOE was not able to identify any information to specify the reasons why consumers purchase gas standard ovens with standing pilots. For example, it is unknown if consumers only purchase gas cooking products with standing pilots because an electrical outlet is not nearby. Therefore, for purposes of conducting the LCC and PBP analysis, DOE allocated shipments of gas cooking products with standing pilots to all households irrespective of the possible need to install an electrical outlet. DOE allocated these shipments assuming that the percentage of the housing stock purchasing gas standard ovens with pilots is equal to the percentage of products still being shipped with standing pilots. Because 57 percent of the gas standard oven household sample is comprised of households built prior to 1960, these households are slightly more likely to be allocated a product with a standing pilot. Because DOE could not conclusively determine whether pre-1960 households would absolutely require the

installation of an outlet, DOE assumed that an outlet would need to be installed to accommodate a gas cooking product that would require electricity to operate. Based on the above percentages of shipments with standing pilots and households built prior to 1960, DOE calculated that 10 percent of the overall gas standard oven household sample (57 percent of households multiplied by 17.6 percent of shipments) would need to install an electrical outlet to accommodate a gas standard oven that requires electricity to operate.

As shown previously in Table 8.2.9, the installation cost of adding an electrical outlet is $235. As will be discussed later in section 8.2.6, the only gas standard ovens that are still shipped with standing pilots are those in gas ranges (comprised of a cooktop and standard oven). Therefore, the cost of any outlet installation is effectively shared between the oven and the cooktop. Thus, the resulting cost for a gas standard oven consumer needing to install an electrical outlet is ½ of $235 or $118.

As discussed above, DOE estimated that 57 percent value of all households with gas cooktops need to install an electrical outlet to accommodate a gas cooktop that needs electricity to operate. As a result, the *average* installation cost for households still purchasing gas standard ovens with standing pilots is 57 percent of $118 or $67.

***Total Installed Cost***

The total installed cost is the sum of the consumer equipment price and the installation cost. Refer back to section 8.2.1 to review the equations that DOE used to calculate the total installed cost for baseline and standard-level products.

Tables 8.2.19 through 8.2.22 present the consumer equipment price, installation costs, and total installed costs for the electric standard, electric self-cleaning, gas standard, and gas self-cleaning oven product classes. Prices and costs are presented at the baseline level and each standard level.

**Table 8.2.19 Electric Standard Ovens: Consumer Equipment Prices, Installation Costs, and Total Installed Costs**

| Standard Level | Energy Factor | Equipment Price (2006$) | Installation Cost (2006$) | Total Installed Cost (2006$) |
|---|---|---|---|---|
| Baseline | 0.1066 | $267.58 | $146.06 | $413.64 |
| 1 | 0.1113 | $269.94 | $146.06 | $416.00 |
| 2 | 0.1163 | $274.60 | $146.06 | $420.66 |
| 3 | 0.1181 | $279.96 | $146.06 | $426.02 |
| 4 | 0.1206 | $337.47 | $146.06 | $483.53 |
| 5 | 0.1209 | $342.62 | $146.06 | $488.68 |

**Table 8.2.20 Electric Self-Cleaning Ovens: Consumer Equipment Prices, Installation Costs, and Total Installed Costs**

| Standard Level | Energy Factor | Equipment Price (2006$) | Installation Cost (2006$) | Total Installed Cost (2006$) |
|---|---|---|---|---|
| Baseline | 0.1099 | $338.63 | $146.06 | $484.69 |
| 1 | 0.1102 | $344.97 | $146.06 | $491.03 |
| 2 | 0.1123 | $402.43 | $146.06 | $548.49 |

**Table 8.2.21 Gas Standard Ovens: Consumer Equipment Prices, Installation Costs, and Total Installed Costs**

| Standard Level | Energy Factor | Equipment Price (2006$) | Installation Cost (2006$) | Total Installed Cost (2006$) |
|---|---|---|---|---|
| Baseline | 0.0298 | $284.26 | $146.06 | $430.32 |
| 1* | 0.0536 | $301.85 | $212.92** | $514.77 |
| 2 | 0.0566 | $307.07 | $212.92** | $519.99 |
| 3 | 0.0572 | $308.65 | $212.92** | $521.57 |
| 4 | 0.0593 | $340.94 | $212.92** | $553.86 |
| 5 | 0.0596 | $343.30 | $212.92** | $556.22 |
| 6 | 0.0600 | $348.60 | $212.92** | $561.52 |
| 1a* | 0.0583 | $306.14 | $212.92** | $519.06 |

***** Levels 1 and 1a correspond to designs that are utilized for the same purpose—eliminate the need for a standing pilot—but the technologies for each design are different. Level 1 is a hot surface ignition device while level 1a is a spark ignition device.

** Added installation cost of $67 is the average cost to gas standard oven consumers that still purchase products with standing pilots.

**Table 8.2.22 Gas Self-Cleaning Ovens: Consumer Equipment Prices, Installation Costs, and Total Installed Costs**

| Standard Level | Energy Factor | Equipment Price (2006$) | Installation Cost (2006$) | Total Installed Cost (2006$) |
|---|---|---|---|---|
| Baseline | 0.0540 | $404.17 | $146.06 | $550.23 |
| 1 | 0.0625 | $420.22 | $146.06 | $566.28 |
| 2 | 0.0627 | $426.59 | $146.06 | $572.65 |
| 3 | 0.0632 | $428.36 | $146.06 | $574.43 |

### 8.2.1.3 Microwave Ovens

***Baseline Manufacturer Cost***

DOE used its 1996 *Technical Support Document for Residential Cooking Products* to develop the baseline manufacturer costs for microwave ovens.[3] Table 8.2.23 provides this baseline manufacturer cost for microwave ovens. Also included in Table 8.2.23 is the associated baseline energy factor and cooking efficiency.

**Table 8.2.23 Microwave Ovens: Baseline Manufacturer Costs**

| Product Class | Baseline Energy Factor | Baseline Cooking Efficiency | Baseline Manufacturer Cost | |
|---|---|---|---|---|
| | | | (1990$)* | (2006$) |
| Microwave Ovens | 0.557 | 55.7% | $120.00 | $112.57 |

*** Source:** U.S. DOE, *Technical Support Document for Residential Cooking Products*, 1996. Table 1.17.

The manufacturer cost data reported in DOE's 1996 *Technical Support Document for Residential Cooking Products* are in 1990$. Because DOE conducted the LCC and PBP analysis in 2006$, it needs to convert all cost data into 2006$. The last column in Table 8.2.23 shows the baseline manufacturer costs in 2006$. To perform the necessary monetary conversion for cooking products, DOE used PPIs for household cooking appliance manufacturers.[4] Refer back to Table 8.2.3 to review the PPIs that DOE used to perform the conversions.

***Standard-Level Manufacturer Cost Increases***

DOE developed manufacturer cost increases associated with increases in product standard levels through the use of its 1996 *Technical Support Document for Residential Cooking Products*. Refer to Chapter 5, Engineering Analysis, for details. Table 8.2.24 summarizes the standard-level manufacturer cost increases for microwave ovens.

**Table 8.2.24 Microwave Ovens: Standard-Level Manufacturer Cost Increases for Energy Factor Levels**

| Standard Level | Energy Factor | Cooking Efficiency | Standard-Level Manufacturer Cost Increase (2006$) |
|---|---|---|---|
| Baseline | 0.557 | 55.7% | - |
| 1 | 0.586 | 58.6% | $8.14 |
| 2 | 0.588 | 58.8% | $16.84 |
| 3 | 0.597 | 59.7% | $30.52 |
| 4 | 0.602 | 60.2% | $47.95 |

***Overall Markup***

As described earlier for cooktops, the overall markup is the value determined by multiplying the manufacturer and retailer markups and the sales tax together to arrive at a single

markup value. Table 8.2.25 shows the overall baseline and incremental markups for microwave ovens. Refer to Chapter 7, Markups for Equipment Price Determination, for details.

**Table 8.2.25 Microwave Ovens: Overall Markups**

| **Markup** | Baseline | Incremental |
|---|---|---|
| Manufacturer | 1.26 | |
| Retailer | 1.45 | 1.15 |
| Sales Tax | 1.0689 | |
| **Overall** | 1.95 | 1.55 |

As described earlier for cooktops, the manufacturer cost data reported in DOE's 1996 *Technical Support Document for Residential Cooking Products* are in 1990$. Because DOE conducted the LCC and PBP analysis in 2006$, it needs to covert all cost data into 2006$. To perform the necessary monetary conversion for cooking products, DOE used PPIs that are applicable to household cooking appliance manufacturers. Refer back to Table 8.2.3 to review the 1990 and 2006 PPIs for electric cooking appliance manufacturers that DOE used to convert manufacturer microwave oven prices from 1990$ to 2006$.

***Installation Cost***

Based on its 1996 *Technical Support Document on Residential Cooking Products*, DOE did not allocate any installation costs for baseline and standard-level microwave ovens.

***Total Installed Cost***

The total installed cost is the sum of the consumer equipment price and the installation cost. Refer back to section 8.2.1 to see the equations that DOE used to calculate the total installed cost for baseline and standard-level products.

Table 8.2.26 presents the consumer equipment prices, installation costs, and total installed costs for microwave ovens. Prices and costs are presented at the baseline level and each standard level.

**Table 8.2.26 Microwave Ovens: Consumer Equipment Prices, Installation Costs, and Total Installed Costs for Energy Factor Levels**

| **Standard Level** | **Energy Factor** | **Equipment Price (2006$)** | **Installation Cost (2006$)** | **Total Installed Cost (2006$)** |
|---|---|---|---|---|
| Baseline | 0.557 | $219.85 | $0.00 | $219.85 |
| 1 | 0.586 | $232.46 | $0.00 | $232.46 |
| 2 | 0.588 | $245.93 | $0.00 | $245.93 |
| 3 | 0.597 | $267.12 | $0.00 | $267.12 |
| 4 | 0.602 | $294.11 | $0.00 | $294.11 |

### 8.2.2 Operating Cost Inputs

DOE defines the operating cost by the following equation:

$$OC = EC + RC + MC$$

where:

*EC* = Energy expenditure associated with operating the equipment,
*RC* = Repair cost associated with component failure, and
*MC* = Service cost for maintaining equipment operation.

Table 8.2.27 shows the inputs for determining the operating costs. The inputs listed in Table 8.2.27 are also necessary for determining lifetime operating expenses, which include the energy price trends, product lifetime, discount rate, and effective date of the standard.

**Table 8.2.27 Inputs for Operating Cost**

| |
|---|
| Annual Energy Consumption |
| Energy Prices |
| Repair and Maintenance Costs |
| Energy Price Trends |
| Product Lifetime |
| Discount Rate |
| Effective Date of Standard |

The *annual energy consumption* is the site energy use associated with operating the equipment. The annual energy consumption vary with the product efficiency. That is, the energy consumption associated with standard-level equipment (i.e., equipment with efficiencies greater than baseline equipment) are less than the consumptions associated with baseline equipment. *Energy prices* are the prices paid by consumers for energy (i.e., electricity, gas, or oil). Multiplying the annual energy consumption by the energy price yields the annual energy cost. *Repair costs* are associated with repairing or replacing components that have failed. *Maintenance costs* are associated with maintaining the operation of the equipment. DOE used *energy price trends* to forecast energy prices into the future and, along with the product lifetime and discount rate, to establish the lifetime energy costs. The *product lifetime* is the age at which the equipment is retired from service. The *discount rate* is the rate at which DOE discounted future expenditures to establish their present value. DOE calculated the operating cost for baseline products based on the following equation:

$$OC_{BASE} = EC_{BASE} + RC_{BASE} + MC_{BASE} = AEC_{BASE} \times PRICE_{ENERGY} + RC_{BASE} + MC_{BASE}$$

where:

$OC_{BASE}$ = Baseline operating cost,
$EC_{BASE}$ = Energy expenditure associated with operating the baseline equipment,
$RC_{BASE}$ = Repair cost associated with component failure for the baseline equipment,
$MC_{BASE}$ = Service cost for maintaining baseline equipment operation,
$AEC_{BASE}$ = Annual energy consumption for baseline equipment, and
$PRICE_{ENERGY}$ = Energy price.

DOE calculated the operating cost for standard-level products based on the following equation:

$$\boldsymbol{OC_{STD} = EC_{STD} + RC_{STD} + MC_{STD} = AEC_{STD} \times PRICE_{ENERGY} + RC_{STD} + MC_{STD}}$$
$$\boldsymbol{= \left(AEC_{BASE} - \Delta AEC_{STD}\right) \times PRICE_{ENERGY} + \left(RC_{BASE} + \Delta RC_{STD}\right) + \left(MC_{BASE} + \Delta MC_{STD}\right)}$$

where:

$OC_{STD}$ = Standard-level operating cost,
$EC_{STD}$ = Energy expenditure associated with operating standard-level equipment,
$RC_{STD}$ = Repair cost associated with component failure for standard-level equipment,
$MC_{STD}$ = Service cost for maintaining standard-level equipment operation,
$AEC_{STD}$ = Annual energy consumption for standard-level equipment,
$PRICE_{ENERGY}$ = Energy price,
$\Delta AEC_{STD}$ = Change in annual energy consumption caused by standard-level equipment,
$\Delta RC_{STD}$ = Change in repair cost caused by standard-level equipment, and
$\Delta MC_{STD}$ = Change in maintenance cost caused by standard-level equipment.

The remainder of this section provides information about each of the above input variables that DOE used to calculate the operating costs for cooking products.

#### 8.2.2.1 Annual Energy Consumption

Chapter 6, Energy Use Determination, details how DOE determined the annual energy consumption for baseline and standard-level products.

As described in Chapter 6 and the beginning of this chapter in section 8.1.1, in the case of cooking products, DOE developed a sample of individual households that use each of the appliances. By developing household samples, DOE was able to perform the LCC and PBP calculations for each household to account for the variability in both energy use and energy price associated with each household. DOE used EIA's 2001 RECS to develop the household samples and, in turn, to establish the variability in both annual energy consumption and energy pricing. Refer back to Chapter 6, sections 6.2.1.4 and 6.2.2.4 to review the variability of annual energy consumption for cooktops and ovens and microwave ovens, respectively.

The tables presented below are based on the energy use determination analysis described in Chapter 6. Keep in mind that the annual energy consumption values in the tables below are averages. DOE captured the variability in energy consumption when it conducted its LCC and PBP analysis.

***Cooktops***

Tables 8.2.28, 8.2.29, and 8.2.30 provide the average annual energy consumption by efficiency level for electric coil, electric smooth, and gas cooktops. Refer back to section 6.2.1.3 from Chapter 6 for more details on how DOE determined the annual energy consumption for cooktops.

**Table 8.2.28 Electric Coil Cooktops: Annual Energy Consumption by Efficiency Level**

| Standard Level | Energy Factor | Annual Energy Consumption |
|---|---|---|
| | | *kWh/year* |
| Baseline | 0.737 | 128.2 |
| 1 | 0.769 | 122.9 |

**Table 8.2.29 Electric Smooth Cooktops: Annual Energy Consumption by Efficiency Level**

| Standard Level | Energy Factor | Annual Energy Consumption |
|---|---|---|
| | | *kWh/year* |
| Baseline | 0.742 | 128.2 |
| 1 | 0.753 | 126.3 |

**Table 8.2.30 Gas Cooktops: Annual Energy Consumption by Efficiency Level**

| Standard Level | Energy Factor | Cooking Efficiency | Cooking | Pilot* | Total |
|---|---|---|---|---|---|
| | | | *MMBtu/year* | *MMBtu/year* | *MMBtu/year* |
| Baseline | 0.156 | 39.9% | 0.72 | 2.01 | 2.74 |
| 1 | 0.399 | 39.9% | 0.72 | - | 0.72 |
| 2 | 0.420 | 42.0% | 0.69 | - | 0.69 |

* Pilot light consumption based on the use of two pilot lights that each use 115 Btu/hr.

***Ovens***

Tables 8.2.31, 8.2.32, 8.2.33, and 8.2.34 provide the average annual energy consumption by efficiency level for electric standard, electric self-cleaning, gas standard, and gas self-cleaning ovens. Refer back to section 6.2.1.3 from Chapter 6 for more details on how DOE determined the annual energy consumption for ovens.

**Table 8.2.31 Electric Standard Ovens: Annual Energy Consumption by Efficiency Level**

| Standard Level | Energy Factor | Cooking Efficiency | Cooking | Clock† | Total |
|---|---|---|---|---|---|
| | | | *kWh/year* | *kWh/year* | *kWh/year* |
| Baseline | 0.1066 | 12.2% | 132.4 | 34.2 | 166.5 |
| 1 | 0.1113 | 12.8% | 125.9 | 34.2 | 160.1 |
| 2 | 0.1163 | 13.4% | 119.7 | 34.2 | 153.9 |
| 3 | 0.1181 | 13.7% | 117.6 | 34.2 | 151.8 |
| 4 | 0.1206 | 14.0% | 70.7 | 34.2 | 149.0 |
| 5 | 0.1209 | 14.1% | 70.6 | 34.2 | 148.6 |

† Clock energy consumption based on clock power of 3.9 Watts.

**Table 8.2.32 Electric Self-Cleaning Ovens: Annual Energy Consumption by Efficiency Level**

| Standard Level | Energy Factor | Cooking Efficiency | Cooking | Self-Clean* | Clock† | Total |
|---|---|---|---|---|---|---|
| | | | *kWh/year* | *kWh/year* | *kWh/year* | *kWh/year* |
| Baseline | 0.1099 | 13.8% | 116.6 | 21.1 | 33.3 | 171.0 |
| 1 | 0.1102 | 13.8% | 116.2 | 21.1 | 33.3 | 170.6 |
| 2 | 0.1123 | 14.2% | 113.5 | 21.1 | 33.3 | 167.9 |

* Self-cleaning energy consumption based on 5.286 kWh/cycle and 4 self-cleaning cycles per year.

† Clock energy consumption based on clock power of 3.8 Watts.

**Table 8.2.33 Gas Standard Ovens: Annual Energy Consumption by Efficiency Level**

| Standard Level | Energy Factor | Cooking Efficiency | Cooking* | | Ignition** | | Total | |
|---|---|---|---|---|---|---|---|---|
| | | | *MMBtu/yr* | *kWh/yr* | *MMBtu/yr* | *kWh/yr* | *MMBtu/yr* | *kWh/yr* |
| Baseline | 0.0298 | 5.9% | 0.82 | - | 1.01 | - | 1.83 | 0.0 |
| 1*** | 0.0536 | 5.8% | 0.84 | - | - | 21.1 | 0.84 | 21.1 |
| 2 | 0.0566 | 6.1% | 0.80 | - | - | 21.1 | 0.80 | 21.1 |
| 3 | 0.0572 | 6.2% | 0.79 | - | - | 21.1 | 0.79 | 21.1 |
| 4 | 0.0593 | 6.5% | 0.75 | 1.8 | - | 21.1 | 0.75 | 22.9 |
| 5 | 0.0596 | 6.5% | 0.75 | 1.8 | - | 21.1 | 0.75 | 22.9 |
| 6 | 0.0600 | 6.6% | 0.74 | 1.8 | - | 21.1 | 0.74 | 22.9 |
| 1a*** | 0.0583 | 5.8% | 0.84 | - | - | - | 0.84 | 0.0 |

* Electrical energy consumption for cooking due to forced convection fan. Measured test energy use of 15 W-hr.

** Gas energy consumption for ignition based on use of one pilot light that uses 115 Btu/hr.
Electrical energy consumption due to hot surface ignition device. Measured test energy use of 176 W-hr.

*** Levels 1 and 1a correspond to designs that are utilized for the same purpose—eliminate the need for a standing pilot—but the technologies for each design are different. Level 1 is a hot surface ignition device while level 1a is a spark ignition device.

**Table 8.2.34 Gas Self-Cleaning Ovens: Annual Energy Consumption by Efficiency Level**

| Std Level | Energy Factor | Cooking Effcy | Cooking* | | Self-Clean** | | Ignition*** | Clock† | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | *MMBtu/yr* | *kWh/yr* | *MMBtu/yr* | *kWh/yr* | *kWh/yr* | *kWh/yr* | *MMBtu/yr* | *kWh/yr* |
| Baseline | 0.0540 | 7.1% | 0.68 | - | 0.17 | 0.7 | 21.1 | 31.5 | 0.86 | 53.3 |
| 1 | 0.0625 | 8.8% | 0.56 | 1.8 | 0.17 | 0.7 | 21.1 | 31.5 | 0.73 | 55.1 |
| 2 | 0.0627 | 8.8% | 0.55 | 1.8 | 0.17 | 0.7 | 21.1 | 31.5 | 0.73 | 55.1 |
| 3 | 0.0632 | 8.9% | 0.55 | 1.8 | 0.17 | 0.7 | 21.1 | 31.5 | 0.72 | 55.1 |

* Electrical energy consumption for cooking due to forced convection fan. Measured test energy use of 15 W-hr.

** Self-cleaning energy consumption based on gas use of 43,158 Btu/cycle, electrical use of 0.171 kWh/cycle, and 4 self-cleaning cycles per year.

*** Electrical energy consumption due to hot surface ignition device. Measured test energy use of 176 W-hr.

† Clock energy consumption based on clock power of 3.6 Watts.

***Microwave Ovens***

Table 8.2.35 provides the average annual energy consumption by efficiency level for microwave ovens. Refer back to section 6.2.2.3 from Chapter 6 for more details on how DOE determined the annual energy consumption for microwave ovens.

**Table 8.2.35 Microwave Ovens: Annual Energy Consumption by Energy Factor Level**

| Standard Level | Energy Factor | Cooking Consumption | | Standby Power Consumption | | Total Energy Consumption |
|---|---|---|---|---|---|---|
| | | Efficiency | Energy Use | Standby Power | Energy Use* | |
| | | | *kWh/year* | *W* | *kWh/year* | *kWh/year* |
| Baseline | 0.557 | 55.7% | 131.0 | 2.83 | 24.6 | 155.6 |
| 1 | 0.586 | 58.6% | 124.5 | 2.83 | 24.6 | 149.1 |
| 2 | 0.588 | 58.8% | 124.1 | 2.83 | 24.6 | 148.7 |
| 3 | 0.597 | 59.7% | 122.2 | 2.83 | 24.6 | 146.8 |
| 4 | 0.602 | 60.2% | 121.2 | 2.83 | 24.6 | 145.8 |

* Annual standby power energy consumption based on 8689 standby hours per year.

### 8.2.2.2 Energy Prices

DOE derived energy prices for 13 geographic areas in the U.S. Using these data, DOE analyzed the variability of energy prices at the regional level for cooking products.

DOE used RECS to develop a sample of individual households that use each of the appliances. By developing household samples, DOE was able to perform the LCC and PBP calculations for each household to account for the regional variability in energy prices associated with each household.

The methodology that DOE used for deriving the energy prices is presented below. Included are tables that summarize the regional energy prices for each product.

### *Energy Prices*

DOE derived average energy prices from data from EIA. DOE calculated prices for each of 13 geographic areas: the nine U.S. Census divisions, with four large States (New York, Florida, Texas, and California) treated separately. For Census divisions containing one of these large States, DOE calculated the regional average values leaving out data for the large State—for example, the Pacific region average does not include California, and the West South Central does not include Texas.

#### Residential Electricity Prices

DOE estimated electricity prices for residential consumers in each of the above geographic areas using EIA Form 861 data.[10] These data are published annually and include annual electricity sales in kilowatt hours (kWh), revenues from electricity sales, and number of consumers, for the residential, commercial, and industrial sectors, for every utility serving final consumers. The calculation of an average residential electricity price proceeds in two steps:

1. For each utility, estimate an average residential price by dividing the residential revenues by residential sales.
2. Calculate a regional average price, weighting each utility with customers in a region by the number of residential consumers served in that region.

Table 8.2.36 shows the results for each geographic region.

**Table 8.2.36 Average Residential Electricity Prices in 2006**

| Geographic Area | Average Price (2006$/kWh) |
|---|---|
| New England | $0.152 |
| Middle Atlantic (excludes NY) | $0.119 |
| East North Central | $0.096 |
| West North Central | $0.082 |
| South Atlantic (excludes FL) | $0.092 |
| East South Central | $0.081 |
| West South Central (excludes TX) | $0.087 |
| Mountain | $0.091 |
| Pacific (excludes CA) | $0.093 |
| New York | $0.167 |
| Florida | $0.109 |
| Texas | $0.120 |
| California | $0.141 |

**Source:** EIA Form 861.

Table 8.2.37 shows the national average residential electricity prices for cooking products based on the relative residential consumer weight of each geographic area. DOE determined the weighting of each geographic area based on the saturation of each appliance in the U.S. DOE

used saturation data from the 2001 RECS to determine how the national saturation of each cooking appliance was distributed over the 13 geographic areas. Because DOE conducted the LCC and PBP analysis in 2006$, all electricity prices are in 2006$.

**Table 8.2.37 Average Residential Electricity Prices for Cooking Products in 2006**

| Geographic Area | Average Price (2006$/kWh) | Saturations* | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Elec Cooktops | Gas Cooktops | Elec Std Ovens | Elec SC Ovens | Gas Std Ovens | Gas SC Ovens | MW Ovens |
| New England | $0.152 | 5.2% | 4.2% | 3.4% | 6.7% | 4.4% | 4.2% | 4.3% |
| Middle Atlantic (excludes NY) | $0.119 | 6.5% | 9.0% | 6.1% | 7.3% | 7.9% | 11.9% | 6.6% |
| East North Central | $0.096 | 14.4% | 19.2% | 13.3% | 16.4% | 18.1% | 23.1% | 16.7% |
| West North Central | $0.082 | 7.3% | 5.6% | 6.8% | 7.5% | 5.7% | 6.9% | 7.5% |
| South Atlantic (excludes FL) | $0.092 | 14.7% | 10.4% | 16.7% | 13.4% | 10.9% | 9.1% | 13.6% |
| East South Central | $0.081 | 8.1% | 3.0% | 9.5% | 6.7% | 3.0% | 2.3% | 6.7% |
| West South Central (excludes TX) | $0.087 | 3.5% | 4.5% | 3.7% | 2.6% | 5.5% | 2.9% | 4.3% |
| Mountain | $0.091 | 7.5% | 4.4% | 6.6% | 8.2% | 5.0% | 3.3% | 6.7% |
| Pacific (excludes CA) | $0.093 | 5.9% | 0.6% | 7.5% | 4.9% | 0.3% | 0.5% | 4.1% |
| New York | $0.167 | 3.8% | 11.1% | 3.0% | 4.3% | 10.7% | 13.0% | 5.6% |
| Florida | $0.109 | 8.7% | 1.2% | 6.3% | 10.3% | 1.4% | 1.4% | 5.9% |
| Texas | $0.120 | 7.3% | 7.6% | 9.0% | 5.4% | 7.8% | 3.5% | 7.2% |
| California | $0.141 | 7.0% | 19.2% | 8.3% | 6.3% | 19.2% | 18.0% | 10.9% |
| **National Average Price (2006$/kWh)** | - | **$0.105** | **$0.117** | **$0.104** | **$0.107** | **$0.116** | **$0.117** | **$0.108** |

* Saturations based on 2001 RECS.

**Residential Natural Gas Prices**

DOE obtained the data for the natural gas price calculation from the EIA publication *Natural Gas Monthly*.[11] This publication includes a compilation of monthly natural gas delivery volumes and average consumer prices by State, for residential, commercial, and industrial customers. The Department used the complete annual data for 2006 to calculate an average annul price for each area. The calculation of average prices proceeds in two steps:

1. Calculate the annul price for each State using a simple average over the appropriate months.
2. Calculate a regional price, weighting each State in a region by its population.

This method differs from the method used to calculate electricity prices because EIA does not provide consumer- or utility-level data on gas consumption and prices. The residential price units in Table 8.2.38 are in dollars per thousand cubic feet ($/tcf).

**Table 8.2.38 Average Residential Natural Gas Prices in 2006**

| Geographic Area | Average Price (2006$/tcf) |
|---|---|
| New England | $18.42 |
| Middle Atlantic (excludes NY) | $16.86 |
| East North Central | $13.73 |
| West North Central | $14.88 |
| South Atlantic (excludes FL) | $19.69 |
| East South Central | $16.73 |
| West South Central (excludes TX) | $15.82 |
| Mountain | $14.45 |
| Pacific (excludes CA) | $17.43 |
| New York | $17.52 |
| Florida | $22.40 |
| Texas | $14.64 |
| California | $12.33 |

**Source:** EIA *Natural Gas Monthly*.

Table 8.2.39 shows the national average residential natural gas prices for gas cooking products based on the relative residential consumer weight of each geographic area. As it did for residential electricity prices, DOE determined the weighting of each geographic area based on the saturation of each appliance in the U.S. using data from 2001 RECS. Because DOE conducted the LCC and PBP analysis in 2006$, all natural gas prices are in 2006$.

**Table 8.2.39 Average Residential Natural Gas Prices for Cooking Products in 2006**

| Geographic Area | Average Price (2006$/MMBtu)** | Saturations* | | |
|---|---|---|---|---|
| | | Gas Cooktops | Gas Std Ovens | Gas SC Ovens |
| New England | $17.86 | 4.2% | 4.4% | 4.2% |
| Middle Atlantic (excludes NY) | $16.35 | 9.0% | 7.9% | 11.9% |
| East North Central | $13.32 | 19.2% | 18.1% | 23.1% |
| West North Central | $14.43 | 5.6% | 5.7% | 6.9% |
| South Atlantic (excludes FL) | $19.09 | 10.4% | 10.9% | 9.1% |
| East South Central | $16.23 | 3.0% | 3.0% | 2.3% |
| West South Central (excludes TX) | $15.34 | 4.5% | 5.5% | 2.9% |
| Mountain | $14.02 | 4.4% | 5.0% | 3.3% |
| Pacific (excludes CA) | $16.91 | 0.6% | 0.3% | 0.5% |
| New York | $16.99 | 11.1% | 10.7% | 13.0% |
| Florida | $21.73 | 1.2% | 1.4% | 1.4% |
| Texas | $14.20 | 7.6% | 7.8% | 3.5% |
| California | $11.96 | 19.2% | 19.2% | 18.0% |
| **National Average Price (2006$/MMBtu)** | **-** | **$14.99** | **$15.00** | **$15.03** |

* Saturations based on 2001 RECS.

** 1 tcf gas = 1.03 MMBtu.

### 8.2.2.3 Energy Price Trends

DOE used price forecasts by the EIA to estimate the trends in natural gas, oil, and electricity prices. To arrive at prices in future years, it multiplied the average prices described in the preceding section (section 8.2.2.2) by the forecast of annual average price changes in EIA's *AEO 2009 Early Release*.[12] To estimate the trend after 2030, DOE followed past guidelines provided to the Federal Energy Management Program (FEMP) by EIA and used the average rate of change during 2020–2030.

The Department calculated LCC and PBP using three separate projections: Reference, Low Economic Growth, and High Economic Growth. These three cases reflect the uncertainty of economic growth in the forecast period. The high and low growth cases show the projected effects of alternative growth assumptions on energy markets. Figures 8.2.1 and 8.2.2 show the residential electricity and natural gas price trends, respectively, based on the three projections. The *AEO 2009 Early Release* provides only forecasts for the reference case. Therefore, DOE scaled the *AEO 2008*[13] high growth case and low-growth forecasts by the ratio of *AEO 2009 Early Release* and *AEO 2008* reference case forecasts to estimate high-growth and low-growth

price trends. For the LCC results presented in section 8.4, DOE used only the energy price forecasts from the *AEO 2009 Early Release* reference case.

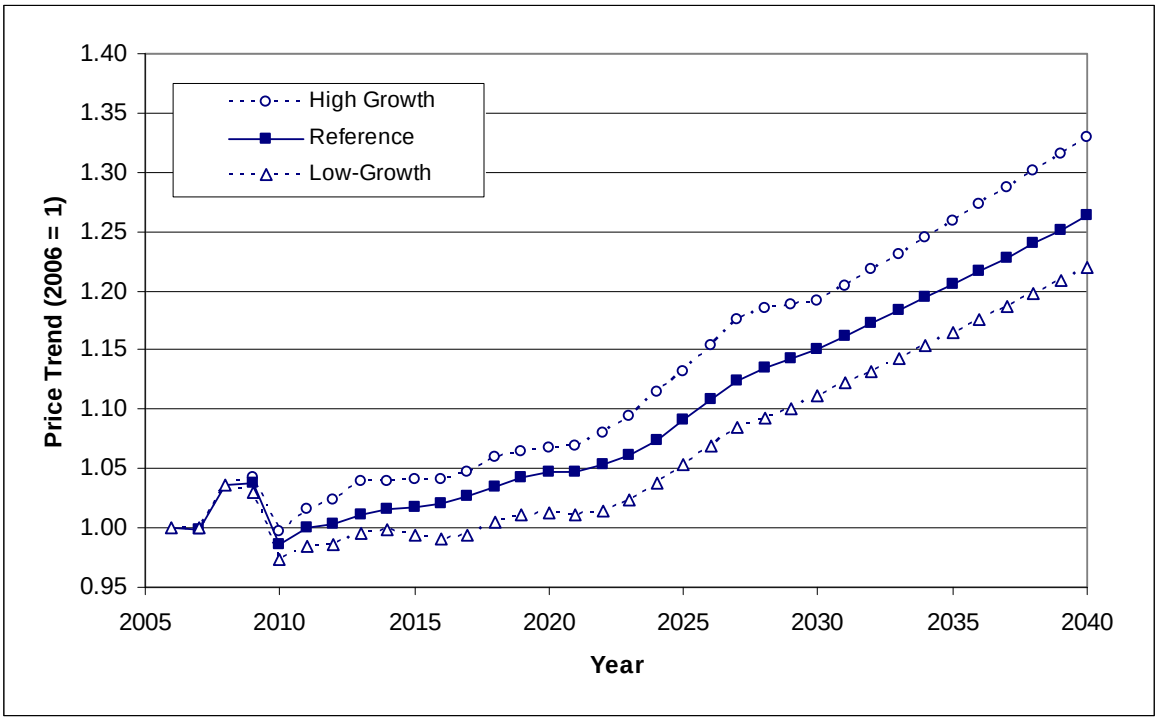


**Figure 8.2.1 Electricity Price Trends**

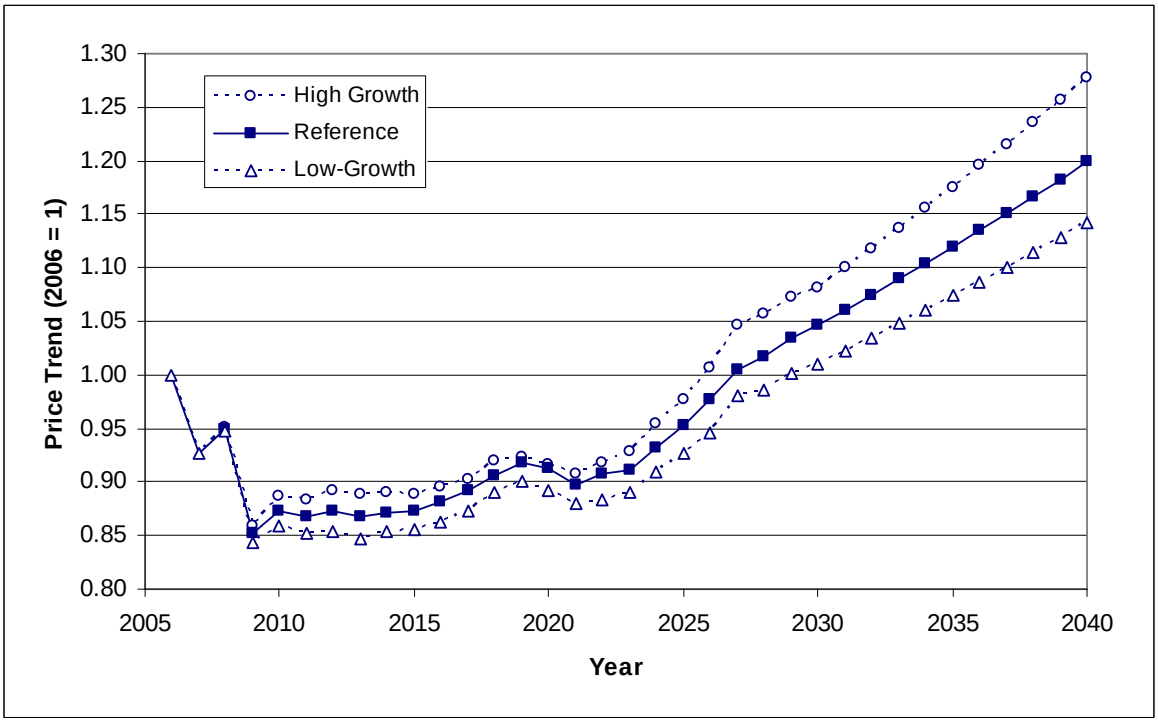


**Figure 8.2.2 Natural Gas Price Trends**

#### 8.2.2.4 Repair and Maintenance Costs

Typically, small incremental changes in product efficiency incur no, or only very small, changes in repair and maintenance costs over baseline products. However, equipment with efficiencies that are significantly higher than the baseline are more likely to incur higher repair and maintenance costs because its higher complexity and higher part count typically increases the cumulative probability of failure.

***Cooking Products***

For all electric cooking products, including microwave ovens, DOE did not include any changes in repair and maintenance costs for products more efficient than baseline products.

For gas cooking products, DOE did determine the repair and maintenance costs associated with different types of ignition systems. DOE contacted six contractors, one each in Arizona, California, Colorado, Massachusetts, Minnesota, and Texas, to estimate whether repair and maintenance costs differ between standing pilot and non-standing pilot ignition systems. Table 8.2.40 summarizes the findings from the discussions with the six contractors.

**Table 8.2.40 Repair/Maintenance Findings for Gas Cooking Product Ignition Systems**

| Ignition System | Findings |
|---|---|
| Standing Pilot | • Rare but found in some apartments, rentals, low-budget kitchens.<br>• Very reliable; repair frequency ranges from 10 years to rare.<br>• Cleaning is most common issue; valves get dirty from grease and impurities in gas.<br>• Estimated costs for cleaning: $85-120 for labor.<br>• Estimated costs for valve replacement: $150.<br>• Average repair/maintenance cost = $126. |
| Glo-bar/hot surface | • Found in approx. 90% of gas ovens (the remaining fraction use standing pilots or more-efficient spark ignitions).<br>• Fragile, typically last only 5 years.<br>• Reasons for failure include burn out, cleaning sprays, jostling, oxidation.<br>• Estimated repair costs range from $125 to $180.<br>• Average repair cost = $147. |
| Electronic spark | • Found in almost all gas cooktops.<br>• Definitely longer-lasting than Glo-bar igniters, but harder to gauge performance statistically. Modules can break after 5 years, while some last the lifetime of the appliance. Average 10 years. Electrodes rarely have problems.<br>• Reasons for failure of spark module include power outage, pinched wire, humidity issues.<br>• Reasons for failure of spark electrode include physical abuse from pots and pans<br>• Estimated repair costs range from $160 to $195.<br>• Average repair cost = $178. |

Based on the contractors' input, DOE determined that standing pilots are less costly to repair and maintain than either electric glo-bar/hot surface ignition systems (used in most gas ovens) or electronic spark ignition systems (used in gas cooktops and a small percentage of gas ovens). For standing pilot ignition systems, DOE determined that repair and maintenance are needed once every 10 years to clean valves. For electric glo-bar/hot surface ignition systems, the glo-bar requires replacement approximately every five years. In the case of electronic ignition systems, control modules tend to last 10 years. The electrodes/igniters can fail due to hard contact from pots or pans, although failures are rare. Based on the above findings, DOE included repair and maintenance costs for gas cooking product ignition systems (see Table 8.2.41).

**Table 8.2.41 Repair/Maintenance Costs for Gas Cooking Product Ignition Systems**

| Ignition System | Repair/Maintenance Cost | Occurrence |
|---|---|---|
| Standing Pilot* | $126 | Once—In the 10th year of Cooking Product's Life |
| Glo-bar/hot surface** | $147 | Every 5th year of Cooking Product's Life |
| Electronic spark*** | $178 | Once—In the 10th year of Cooking Product's Life |

* Applicable to baseline level equipment for gas cooktops and gas standard ovens.

** Applicable to standard level 1 for gas standard ovens and the baseline level for gas self-clean ovens.

*** Applicable to standard level 1 for gas cooktops and standard level 1a for gas standard ovens.

## 8.2.3 Product Lifetime

DOE used only primary sources of data to estimate product lifetimes. The sources DOE used to estimate product lifetimes for cooking products are presented below.

### 8.2.3.1 Cooktops and Ovens

For cooktops and ovens, DOE considered the sources listed in Table 8.2.42 to estimate product lifetimes.

**Table 8.2.42 Cooktops and Ovens: Product Lifetime Estimates and Sources**

| Lifetime (years) | Source |
|---|---|
| Gas Ranges*: Mean = 15; Low = 12; High = 18<br>Electric Ranges*: Mean = 13; Low = 10; High = 16 | Appliance Magazine (2005) [14] |
| Gas & Electric Cooking Products: 19 | DOE TSD (1996) [3] |
| Gas Ranges: 20** | CALMAC (2000) [15] |

* Estimates are first-ownership length, not full product lifetime.

** Based on engineering judgment.

The estimates from *Appliance Magazine* are "based on first-owner use of the product and does not necessarily mean the appliance is worn out." In other words, *Appliance Magazine*'s lifetime estimates underestimate the actual lifetime of the products in those cases where the product is used by two or more users. As a result, DOE used the 19-year estimate from its 1996 *Technical Support Document (TSD) for Cooking Products* to estimate the average product lifetime for both electric and gas cooktops and ovens. DOE used the low estimates from *Appliance Magazine* to establish the minimum product lifetime. To establish the maximum product lifetime, DOE took the difference between the minimum and average values (nine years for electric products and seven years for gas products) and added them to the average product lifetime. The minimum, average, and maximum lifetime estimates are shown in Table 8.2.43.

**Table 8.2.43 Cooktops and Ovens: Average, Minimum, and Maximum Product Lifetimes**

| Product | Minimum *years* | Average *years* | Maximum *years* |
|---|---|---|---|
| Cooktops | | | |
| Electric | 10.0 | 19.0 | 28.0 |
| Gas | 12.0 | 19.0 | 26.0 |
| Ovens | | | |
| Electric | 10.0 | 19.0 | 28.0 |
| Gas | 12.0 | 19.0 | 26.0 |

DOE characterized the cooktop and oven product lifetimes with Weibull distributions. Appendix 8C presents the Weibull distributions of electric and gas cooktops and ovens that DOE used in the LCC and PBP analysis.

### 8.2.3.2 Microwave Ovens

For microwave ovens, DOE considered the sources listed in Table 8.2.44 to estimate product lifetime.

**Table 8.2.44 Microwave Ovens: Product Lifetime Estimates and Sources**

| Lifetime (years) | Source |
|---|---|
| Mean* = 9; Low* = 7; High* = 10 | Appliance Magazine (2005) [14] |
| 10 | DOE TSD (1996) [3] |

* Estimates are first-ownership length, not full product lifetime.

As discussed above for ovens and cooktops, the estimates from *Appliance Magazine* are "based on first-owner use of the product and does not necessarily mean the appliance is worn out." In other words, *Appliance Magazine*'s lifetime estimates underestimate the actual lifetime of the products in those cases where the product is used by two or more users. As a result, DOE considered using the 10-year estimate from its 1996 *TSD for Cooking Products* to estimate the average product lifetime. However, because the 10-year lifetime estimate from DOE's 1996 TSD is the same as the high estimate from *Appliance Magazine*, DOE decided to use only the estimates from *Appliance Magazine* to establish the distribution of product lifetimes. DOE used the low, average, and high estimates from *Appliance Magazine* to establish the minimum, average, and maximum product lifetimes as shown in Table 8.2.45.

**Table 8.2.45 Microwave Ovens: Average, Minimum, and Maximum Product Lifetimes**

| Product | Minimum *years* | Average *years* | Maximum *years* |
|---|---|---|---|
| Microwave Ovens | 7.0 | 9.0 | 10.0 |

DOE characterized microwave oven product lifetimes with Weibull distributions. Appendix 8C presents the Weibull distributions of microwave ovens that DOE used in the LCC and PBP analysis.

### 8.2.4 Discount Rates

DOE derived the discount rates for the LCC and PBP analysis from estimates of the finance cost of purchasing the considered products. Following financial theory, the finance cost of raising funds to purchase appliances can be interpreted as: (1) the financial cost of any debt incurred to purchase equipment, or (2) the opportunity cost of any equity used to purchase equipment. For the residential products, the purchase of equipment for new homes entails different finance costs for consumers than the purchase of replacement equipment. Thus, DOE used different discount rates for new construction and replacement installations.

#### 8.2.4.1 Discount Rate for New Housing Equipment

New-housing equipment is purchased as part of the home, which is almost always financed with a mortgage loan. The Department estimated discount rates for new-housing equipment using the effective real (after-inflation) mortgage rate for homebuyers. This rate corresponds to the interest rate after deduction of mortgage interest for income tax purposes and after adjusting for inflation (using the Fisher formula).[a] For example, a six-percent nominal mortgage rate has an effective nominal rate of 4.5 percent for a household at the 25-percent marginal tax rate. When adjusted for inflation of two percent, the effective real rate becomes 2.45 percent.

The data source DOE used for mortgage interest rates is the Federal Reserve Board's *Survey of Consumer Finances (SCF)* in 1989, 1992, 1995, 1998, 2001, and 2004.[16] Using the appropriate *SCF* data for each year, DOE adjusted the mortgage interest rate for each relevant household in the *SCF* for mortgage tax deduction and inflation (see Table 8.2.46). In cases where the effective interest rate is equal to or below the inflation rate (resulting in a negative real interest rate), DOE set the real effective interest rate to zero.

The average nominal mortgage rate carried by homeowners in these six years was 8.1 percent. Since the mortgage rates carried by households in these years were established over a range of time, DOE believes they are representative of rates that may be in effect in 2012 (the assumed effective date of new efficiency standards – see Section 8.2.5). After adjusting for

[a] Fisher formula is given by: Real Interest Rate = [(1 + Nominal Interest Rate) / (1 + Inflation Rate)] – 1.

inflation and interest tax deduction, effective real interest rates on mortgages across the six surveys averaged 3.2 percent.

**Table 8.2.46 Data Used to Calculate Real Effective Mortgage Rates**

| Year | Average Nominal Interest Rate (%) | Inflation Rate[17] (%) | Marginal Tax Rate applicable to Mortgage Interest[18] (%)* | Average Real Effective Interest Rate (%) |
|---|---|---|---|---|
| 1989 | 9.7 | 4.82 | 23.7 | 2.5 |
| 1992 | 9.1 | 3.01 | 22.9 | 3.9 |
| 1995 | 8.2 | 2.83 | 23.8 | 3.4 |
| 1998 | 7.9 | 1.56 | 23.7 | 4.4 |
| 2001 | 7.6 | 2.85 | 22.6 | 3.0 |
| 2004 | 6.2 | 2.66 | 19.6 | 2.3 |
| *Average* | 8.1 | | | 3.2 |

* The values given are the inverse of the marginal tax rate on mortgage interest.

To account for variation among new households, DOE sampled a rate for each household from a distribution of rates. DOE developed a probability distribution of interest rates based on the *SCF* data. Appendix 8D presents the probability distribution of interest rates that DOE used in the LCC and PBP analysis.

#### 8.2.4.2 Discount Rate for Residential Replacement Equipment

Households use a variety of methods to finance replacement equipment. In principle, one could estimate the interest rates on the actual financing vehicles used to purchase replacement equipment. The shares of different financing vehicles in total replacement equipment purchases are unknown, however.

DOE's approach involves identifying all possible debt or asset classes that might be used to purchase replacement equipment, including household assets that might be affected indirectly.[b] DOE did not include debt from primary mortgages and equity of assets considered non-liquid (such as retirement accounts), since these would likely not be affected by replacement equipment purchases. DOE estimated the average shares of the various debt and equity classes in the average U.S. household equity and debt portfolios using *SCF* data for 1989, 1992, 1995, 1998, 2001, and 2004. Table 8.2.47 shows the average shares of each considered class. DOE used the mean share of each class across the six years as a basis for estimating the effective financing of replacement equipment.

[b] An indirect effect would arise if a household sold some assets in order to pay off a loan or credit card debt that might have been used to finance the actual appliance purchase.

**Table 8.2.47 Average Shares of Considered Household Debt and Equity Types**

| Type | 1989 SCF | 1992 SCF | 1995 SCF | 1998 SCF | 2001 SCF | 2004 SCF | Mean (%) |
|---|---|---|---|---|---|---|---|
| Home equity loans | 4.3 | 4.5 | 2.7 | 2.8 | 2.8 | 4.4 | 3.6 |
| Credit cards | 1.6 | 2.1 | 2.6 | 2.2 | 1.7 | 2.0 | 2.0 |
| Other installment loans | 2.8 | 1.7 | 1.4 | 1.7 | 1.1 | 1.3 | 1.7 |
| Other residential loans | 4.4 | 6.9 | 5.2 | 4.3 | 3.1 | 5.8 | 4.9 |
| Other line of credit | 1.1 | 0.6 | 0.4 | 0.2 | 0.3 | 0.5 | 0.5 |
| Checking accounts | 5.8 | 4.7 | 4.9 | 3.9 | 3.6 | 4.2 | 4.5 |
| Savings & money market | 19.2 | 18.8 | 14.0 | 12.8 | 14.2 | 15.1 | 15.7 |
| Certificate of deposit (CD) | 14.5 | 11.7 | 9.4 | 7.0 | 5.4 | 5.9 | 9.0 |
| Savings bond | 2.2 | 1.7 | 2.2 | 1.1 | 1.2 | 0.9 | 1.5 |
| Bonds | 13.8 | 12.3 | 10.5 | 7.0 | 7.9 | 8.4 | 10.0 |
| Stocks | 22.4 | 24.0 | 25.9 | 36.9 | 37.5 | 28.0 | 29.1 |
| Mutual funds | 8.0 | 11.1 | 20.9 | 20.1 | 21.3 | 23.4 | 17.5 |
| Total | 100 | 100 | 100 | 100 | 100 | 100 | 100 |

DOE estimated interest or return rates associated with each type of equity and debt. The data source for the interest rates for loans, credit cards, and lines of credit is the Federal Reserve Board's *SCF* in 1989, 1992, 1995, 1998, 2001, and 2004. Table 8.2.48 shows the average nominal rates in each year, and the inflation rates used to calculate real rates. For home equity loans, DOE calculated effective interest rates in a similar manner as for mortgage rates, since interest on such loans is tax deductible. Table 8.2.49 shows the average effective real rates in each year and the mean rate across the years. Since the interest rates for each debt carried by households in these years were established over a range of time, DOE believes they are representative of rates that may be in effect in 2012.

**Table 8.2.48 Average Nominal Interest Rates for Household Debt Classes (percent)**

| Type | 1989 SCF | 1992 SCF | 1995 SCF | 1998 SCF | 2001 SCF | 2004 SCF | Mean (%) |
|---|---|---|---|---|---|---|---|
| Home equity loans | 11.5 | 9.6 | 9.6 | 9.8 | 8.7 | 5.7 | 9.2 |
| Credit cards* | - | - | 14.2 | 14.5 | 14.2 | 11.7 | 13.6 |
| Other installment loans | 9.0 | 7.8 | 9.3 | 7.8 | 8.7 | 7.4 | 8.3 |
| Other residential loans | 8.8 | 7.6 | 7.7 | 7.7 | 7.5 | 6.0 | 7.5 |
| Other line of credit | 14.8 | 12.7 | 12.4 | 11.9 | 14.7 | 8.8 | 12.5 |
| Inflation rate | 4.82 | 3.01 | 2.83 | 1.56 | 2.85 | 2.66 | |

* No interest rate data available for credit cards in 1989 or 1992.

**Table 8.2.49 Average Real Effective Interest Rates for Household Debt Classes (percent)**

| Type | 1989 SCF | 1992 SCF | 1995 SCF | 1998 SCF | 2001 SCF | 2004 SCF | Mean (%) |
|---|---|---|---|---|---|---|---|
| Home equity loans | 3.8 | 4.3 | 4.4 | 5.8 | 3.8 | 1.9 | 4.0 |
| Credit cards* | - | - | 11.0 | 12.7 | 11.1 | 9.1 | 11.0 |
| Other installment loans | 4.9 | 5.8 | 7.0 | 6.6 | 6.1 | 5.4 | 6.0 |
| Other residential loans | 4.0 | 4.7 | 4.8 | 6.0 | 4.6 | 3.3 | 4.6 |
| Other line of credit | 9.6 | 9.4 | 9.3 | 10.2 | 7.3 | 6.0 | 8.7 |

* No interest rate data available for credit cards in 1989 or 1992.

To account for variation among new households, DOE sampled a rate for each household from a distribution of rates for each of the above debt classes. DOE developed a probability distribution of interest rates for each debt class based on the *SCF* data. Appendix 8D presents the probability distribution of interest rates for each debt class that DOE used in the LCC and PBP analysis.

Similar rate data are not available from the *SCF* for the asset classes, so the Department derived data for these classes from national-level historical data. The interest rates associated with certificates of deposit (CDs), [19] savings bonds,[20] and bonds (AAA corporate bonds) [21] are from Federal Reserve Board time-series data covering 1977–2007. DOE assumed rates on checking accounts to be zero. Rates on savings and money market accounts are from Cost of Savings Index data covering 1984–2007.[22] The rates for stocks are the annual returns on the Standard and Poor's (S&P) 500 in the 1977–2007 period.[23] The mutual fund rates are a weighted average of the stock rates (two-thirds weight) and the bond rates (one-third weight) in each year of the 1977–2007 period. DOE adjusted the nominal rates to real rates using the annual inflation rate in each year. Average nominal and real interest rates for the classes of assets are shown in Table 8.2.50. Since the interest and return rates for each asset type cover a range of time, DOE believes they are representative of rates that may be in effect in 2012.

**Table 8.2.50 Average Nominal and Real Interest Rates for Household Equity Types**

| Type | Average Nominal Rate (%) | Average Real Rate (%) |
|---|---|---|
| Checking accounts | - | 0.0 |
| Savings and money market | 5.4 | 2.3 |
| CDs | 6.8 | 2.4 |
| Savings bonds | 7.8 | 3.4 |
| Bonds | 8.6 | 4.1 |
| Stocks | 13.2 | 8.6 |
| Mutual funds | 11.4 | 6.8 |

To account for variation among new households, DOE sampled a rate for each household from a distribution of rates for each of the above asset types. DOE developed a normal probability distribution of interest rates for each asset type by using the mean value and standard

deviation from the distribution. Appendix 8D presents the probability distribution of interest rates for each asset type that DOE used in the LCC and PBP analysis.

Table 8.2.51 summarizes the mean real effective rates of each type of equity or debt. DOE determined the average share of each debt and asset using *SCF* data for 1989, 1992, 1995, 1998, 2001, and 2004. Each year of SCF data provides the debt and asset shares for U.S. households. DOE averaged the debt and asset shares over the six years of survey data to arrive at the shares shown in Table 8.2.51 below. The average rate across all types of household debt and equity, weighted by the shares of each class, is 5.5 percent.

**Table 8.2.51 Shares and Interest or Return Rates Used for Household Debt and Equity Types**

| Type | Average Share of Household Debt plus Equity (%)* | Mean Effective Real Rate (%)** |
|---|---|---|
| Home equity loans | 3.6 | 4.0 |
| Credit cards | 2.0 | 11.0 |
| Other installment loans | 1.7 | 6.0 |
| Other residential loans | 4.9 | 4.6 |
| Other line of credit | 0.5 | 8.7 |
| Checking accounts | 4.5 | 0.0 |
| Savings and money market accounts | 15.7 | 2.3 |
| CDs | 9.0 | 2.4 |
| Savings bonds | 1.5 | 3.4 |
| Bonds | 10.0 | 4.1 |
| Stocks | 29.1 | 8.6 |
| Mutual funds | 17.5 | 6.8 |
| **Total/Weighted-average discount rate** | 100 | **5.5** |

* Not including primary mortgage or retirement accounts.

** Adjusted for inflation and, for home equity loans, loan interest tax deduction.

### 8.2.5 Effective Date of Standard

The effective date is the future date when a new standard becomes operative. Based on DOE's implementation report for energy conservation standards activities submitted pursuant to Section 141 of the Energy Policy Act of 2005, a final rule for the home appliances being considered for this standards rulemaking is scheduled for completion in March 2009.[24] Therefore, the effective date of any new energy efficiency standards for these products will be three years after the final rule is published, which is March 2012. The Department calculated the LCC for all consumers as if they each would purchase a new piece of equipment in the year the standard takes effect.

### 8.2.6 Equipment Assignment for the Base Case

For purposes of conducting the LCC analysis, DOE analyzed standard levels relative to a baseline efficiency level. However, some consumers already purchase products with efficiencies greater than the baseline levels. Thus, to accurately estimate the percentage of consumers that would be affected by a particular standard level, DOE took into account the distribution of product efficiencies currently in the marketplace. In other words, rather than analyzing the impacts of a particular standard level assuming that all consumers are currently purchasing products at the baseline level, DOE conducted the analysis by taking into account the full breadth of product efficiencies that consumers purchase under the base case (i.e., the case without new energy efficiency standards).

As noted in section 8.1.1, DOE's approach for conducting the LCC analysis for residential cooking products relied on developing samples of households that use each of the products. DOE used a Monte Carlo simulation technique to perform the LCC calculations on the households in the sample. Using the current distribution of product efficiencies, DOE assigned each household in the sample a unique product efficiency. Because it performed the LCC calculations on a household-by-household basis, DOE based the LCC for a particular standard-level on the efficiency of the product in the given household. For example, if a household was assigned a product efficiency that is greater than or equal to the efficiency of the standard level under consideration, the LCC calculation would reveal that this household is not impacted by an increase in product efficiency that is equal to the standard level.

The product efficiency distributions that DOE used for cooking products in the LCC analysis are discussed in detail below.

#### 8.2.6.1 Cooktops

Because DOE currently does not regulate cooktop efficiency with an energy efficiency descriptor, very little is known regarding the distribution of product efficiencies that consumers in the United States currently purchase.

As discussed in Section 3.14.3 of Chapter 3, Market and Technology Assessment, Natural Resources Canada (NRCanada) does publish the efficiency of electric cooking products sold in Canada. Although the range in electric cooktop efficiency is relatively wide, the distribution is based on the number of models being sold rather than the percent of shipments being sold. Thus, because it is unknown how representative NRCanada's electric cooktop efficiency distribution is of actual shipments sold in the U.S., DOE did not use NRCanada's data for the LCC analysis. Instead, DOE conducted the LCC analysis for electric cooktops assuming that 100 percent of consumers currently purchase products at the baseline efficiency level.

For gas cooktops, even less is known about model efficiency, since neither NRCanada nor AHAM publish any data on gas cooktop efficiencies. However, data are available that establish the percent of gas cooktops that are shipped with standing pilots. Based on shipments data submitted by AHAM for the years 2003–2005, gas standard (i.e., non-self-cleaning) ranges

are the only product type that are still shipped with standing pilots.[25] In other words, all shipments of built-in gas cooktops, built-in ovens, and gas self-cleaning ranges use pilotless ignition systems. Table 8.2.52 shows the historical percentage of gas standard range and gas built-in cooktop shipments with pilots. The historical percentages from 1988 to 1996 are based on data from DOE's supplemental analysis to its 1996 TSD on Cooking Products.[3] Data for the years 1997, 2000, and 2004 are based on information from the Appliance Recycling Information Center (ARIC).[26] The ARIC states that approximately 690,000, 620,000, and 250,000 gas ranges were shipped with standing pilot ignition systems for the years 1997, 2000, and 2004, respectively. Figure 8.2.3 plots the data in Table 8.2.52 to graphically depict the decreasing percentage in gas cooktops with pilots.

**Table 8.2.52 Gas Cooktops: Percent of Shipments with Pilots**

| Year | Percent Shipments with Gas Pilots* | | |
|---|---|---|---|
| | **Built-In Cooktops** | **Standard Ranges** | **All Cooktops (Built-In and Ranges)** |
| 1988 | 16.5% | 48.1% | 32.4% |
| 1989 | 15.4% | 44.1% | 30.8% |
| 1990 | 9.7% | 38.2% | 26.4% |
| 1991 | 8.1% | 36.5% | 24.5% |
| 1992 | 10.4% | 37.6% | 25.1% |
| 1993 | 8.3% | 34.3% | 21.7% |
| 1994 | 12.6% | 39.9% | 26.4% |
| 1995 | 3.3% | 38.5% | 23.2% |
| 1996 | NA | 36.4% | NA |
| 1997 | 0.0% | 47.0% | 25.8% |
| 2000 | 0.0% | 42.8% | 20.0% |
| 2004 | 0.0% | 18.2% | 6.8% |

* **Source:** 1988-1996: U.S. Department of Energy, *Supplemental Analysis for Ranges and Ovens*, Supplemental Chapter 4, 1998. 1997, 2000, 2004, Standard Ranges: Appliance Recycling Information Center, 2005. 2004, Cooktops: AHAM data submittal, 2006.

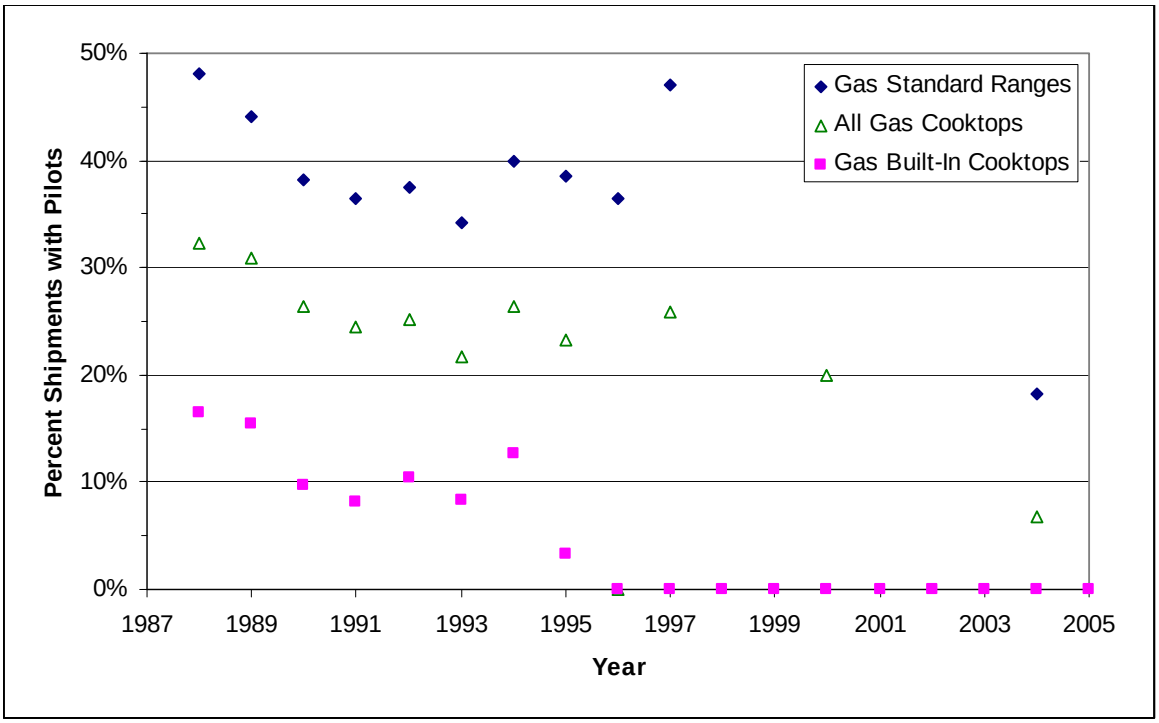


**Figure 8.2.3 Gas Cooktops: Percent of Shipments with Pilots**

Based on the data presented in Table 8.2.52, DOE conducted the LCC analysis for gas cooktops assuming that only 6.8 percent of consumers currently purchase products at the baseline efficiency level. DOE assumed that the remaining 93.2 percent of consumers purchased gas cooktops with pilotless ignition systems.

Table 8.2.53 presents the market shares of the efficiency levels in the base case for each of the cooktop product classes. The market shares represent the equipment that households would have purchased in the year 2012 in the absence of new standards.

**Table 8.2.53 Cooktops: Base Case Market Shares**

| Electric Coil | | | Electric Smooth | | | Gas | | |
|---|---|---|---|---|---|---|---|---|
| **Standard Level** | **EF** | **Market Share** | **Standard Level** | **EF** | **Market Share** | **Standard Level** | **EF** | **Market Share** |
| Baseline | 0.737 | 100% | Baseline | 0.742 | 100% | Baseline | 0.156 | 6.8% |
| 1 | 0.769 | 0% | 1 | 0.753 | 0% | 1 | 0.399 | 93.2% |
| | | | | | | 2 | 0.420 | 0% |

### 8.2.6.2 Ovens

Like cooktops, because DOE does not currently regulate oven efficiency with an energy efficiency descriptor, very little is known regarding the distribution of product efficiencies that consumers currently purchase.

As discussed in Section 3.14.3 of Chapter 3, Market and Technology Assessment, NRCanada does publish the efficiency of electric oven products sold in Canada. Although the range in electric oven efficiency is relatively wide, the distribution is based on the number of models being sold rather than the percent of shipments being sold. Thus, because it is unknown how representative NRCanada's electric oven efficiency distribution is of actual shipments sold in the U.S., DOE did not use NRCanada's data for this analysis. Instead, DOE conducted the LCC analysis for electric ovens assuming that 100 percent of consumers currently purchase products at the baseline efficiency level.

As discussed above for gas cooktops, little is known about gas oven model efficiency, since neither NRCanada nor AHAM publish any data on gas oven efficiencies. However, data are available that establish the percent of gas ovens that are shipped with standing pilots. Based on shipments data that AHAM submitted for the years 2003–2005, gas standard (i.e., non-self-cleaning) ranges are the only product type that are still shipped with standing pilots.[25] Table 8.2.54 shows the historical percentage of gas standard range and gas built-in oven shipments with pilots. DOE based the historical percentages from 1988 to 1996 on data from DOE's supplemental analysis to its 1996 TSD on Cooking Products.[3] Data for the years 1997, 2000, and 2004 are based on information from ARIC.[26] Figure 8.2.4 plots the data in Table 8.2.54 to graphically depict the decreasing percentage in gas ovens with pilots.

**Table 8.2.54 Gas Standard Ovens: Percent of Shipments with Pilots**

| Year | Percent Shipments with Gas Pilots* | | |
|---|---|---|---|
| | **Built-In Standard Ovens** | **Standard Ranges** | **All Standard Ovens (Built-In and Ranges)** |
| 1988 | 1.7% | 48.1% | 44.6% |
| 1989 | 3.1% | 44.1% | 41.6% |
| 1990 | 5.6% | 38.2% | 36.5% |
| 1991 | 0.0% | 36.5% | 34.8% |
| 1992 | 0.0% | 37.6% | 35.9% |
| 1993 | 0.0% | 34.3% | 32.9% |
| 1994 | 0.0% | 39.9% | 38.4% |
| 1995 | 0.0% | 38.5% | 37.0% |
| 1996 | NA | 36.4% | 34.9% |
| 1997 | 0.0% | 47.0% | 45.4% |
| 2000 | 0.0% | 42.8% | 41.3% |
| 2004 | 0.0% | 18.2% | 17.6% |

* **Source:** 1988-1996: U.S. Department of Energy, *Supplemental Analysis for Ranges and Ovens*, Supplemental Chapter 4, 1998. 1997, 2000, 2004, Standard Ranges: Appliance Recycling Information Center, 2005. 2004, Ovens: AHAM data submittal, 2006.

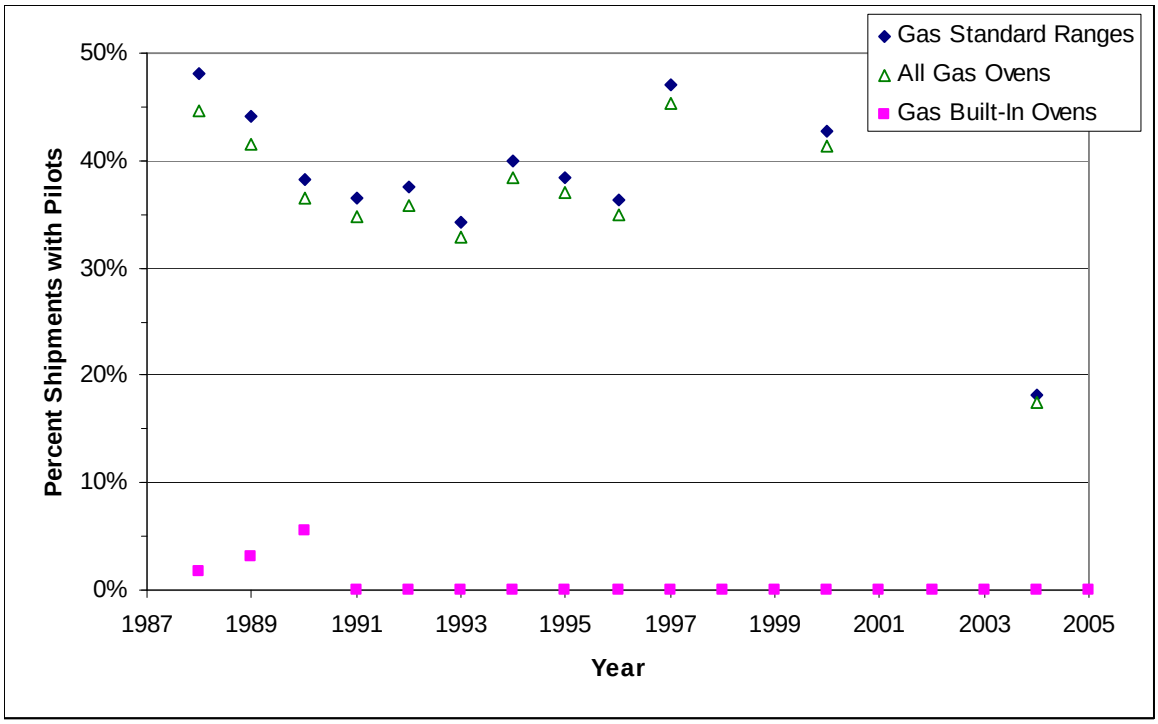


**Figure 8.2.4 Gas Standard Ovens: Percent of Shipments with Pilots**

Based on the data presented in Table 8.2.54, DOE conducted the LCC analysis for gas ovens assuming that only 17.6 percent of consumers currently purchase products at the baseline efficiency level. DOE assumed that the remaining 82.4 percent of consumers purchase gas ovens with pilotless ignition systems (i.e., products at efficiency level 1—glo-bar ignition systems or efficiency level 1a—electronic spark ignition systems). Based on information collected during the course of DOE's contacts with contractors to establish the repair and maintenance costs of gas cooking product ignition systems (see section 8.2.2.4), DOE estimates 90 percent of pilotless ignition systems utilize glo-bar igntion while the remaining ten percent utilize spark ignition systems.

All gas self-cleaning ovens already have pilotless ignition systems (i.e., the baseline efficiency level uses pilotless ignition). Because virtually nothing is known about the distribution of gas self-cleaning oven product efficiencies, DOE conducted the LCC analysis for gas self-cleaning ovens assuming that 100 percent of consumers currently purchase products at the baseline efficiency level.

Table 8.2.55 presents the market shares of the efficiency levels in the base case for each of the oven product classes. The market shares represent the equipment that households would have purchased in the year 2012 in the absence of new standards.

**Table 8.2.55 Ovens: Base Case Market Shares**

| Electric Standard | | | Electric Self-Clean | | | Gas Standard | | | Gas Self-Clean | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Std Level | EF | Market Share | Std Level | EF | Market Share | Std Level | EF | Market Share | Std Level | EF | Market Share |
| Baseline | 0.1066 | 100% | Baseline | 0.1099 | 100% | Baseline | 0.0298 | 17.6% | Baseline | 0.0540 | 100% |
| 1 | 0.1113 | 0% | 1 | 0.1102 | 0% | 1* | 0.0536 | 74.2% | 1 | 0.0625 | 0% |
| 2 | 0.1163 | 0% | 2 | 0.1123 | 0% | 2 | 0.0566 | 0% | 2 | 0.0627 | 0% |
| 3 | 0.1181 | 0% | | | | 3 | 0.0572 | 0% | 3 | 0.0632 | 0% |
| 4 | 0.1206 | 0% | | | | 4 | 0.0593 | 0% | | | |
| 5 | 0.1209 | 0% | | | | 5 | 0.0596 | 0% | | | |
| | | | | | | 6 | 0.0600 | 0% | | | |
| | | | | | | 1a* | 0.0583 | 8.2% | | | |

* For gas standard ovens, levels 1 and 1a correspond to designs that are utilized for the same purpose—eliminate the need for a standing pilot—but the technologies for each design are different. Level 1 is a hot surface ignition device while level 1a is a spark ignition device.

#### 8.2.6.3 Microwave Ovens

Because DOE does not currently regulate microwave oven efficiency with an energy efficiency descriptor, very little is known regarding the distribution of product efficiencies that consumers currently purchase.

As discussed in Section 3.14.3 of Chapter 3, Market and Technology Assessment, AHAM did provide limited data on microwave oven efficiency. Oven efficiencies (i.e., energy factor) that AHAM provided ranged from 55 percent to 62 percent. It is unknown how representative this range of microwave oven efficiencies is of products currently being sold. Therefore, DOE assumed that 100 percent of the market is at the baseline level.

**Table 8.2.56 Microwave Ovens: Base Case Market Shares by Energy Factor Level**

| Standard Level | EF | Annual Energy Use (kWh/yr) | Market Share |
|---|---|---|---|
| Baseline | 0.557 | 165.8 | 100% |
| 1 | 0.586 | 159.3 | 0% |
| 2 | 0.588 | 158.8 | 0% |
| 3 | 0.597 | 157.0 | 0% |
| 4 | 0.602 | 156.0 | 0% |

## 8.3 PAYBACK PERIOD INPUTS

The payback period is the amount of time it takes the consumer to recover the assumed higher purchase expense of more energy-efficient equipment as a result of lower operating costs.

Numerically, the PBP is the ratio of the increase in purchase expense (i.e., from a less efficient design to a more efficient design) to the decrease in annual operating expenditures. This type of calculation is known as a "simple" payback period, because it does not take into account changes in operating expense over time or the time value of money; i.e., the calculation is done at an effective discount rate of zero percent.

The equation for PBP is:

$$PBP = \frac{\Delta IC}{\Delta OC}$$

where:

$\Delta IC$ = Difference in the total installed cost between the more efficient standard level and the baseline design, and
$\Delta OC$ = difference in annual operating expenses.

Payback periods are expressed in years. Payback periods greater than the life of the product mean that the increased total installed cost is not recovered in reduced operating expenses.

The data inputs to PBP are the total installed cost of the equipment to the consumer for each efficiency level and the annual (first year) operating expenditures for each standard level. The inputs to the total installed cost are the equipment price and the installation cost. The inputs to the operating costs are the annual energy cost, the annual repair cost, and the annual maintenance cost. The PBP uses the same inputs as the LCC analysis as described in section 8.2, except that energy price trends and discount rates are not required. Since the PBP is a "simple" payback, the required energy price is only for the year in which a new standard is to take effect—in this case, the year 2012. The energy price DOE used in the PBP calculation was the price projected for that year. Discount rates are also not required for the simple PBP calculation.

## 8.4 LIFE-CYCLE COST AND PAYBACK PERIOD RESULTS

This section presents the LCC and PBP results for cooking products. With regard to the cooking products, as discussed in section 8.1.1, DOE's approach for conducting the LCC analysis relied on developing samples of households that use each of the products. DOE also characterized the uncertainty of many of the inputs to the analysis with probability distributions. DOE used a Monte Carlo simulation technique to perform the LCC calculations on the households in the sample. For each set of sample households using the equipment in each product class, DOE calculated the average LCC and LCC savings and the median and average PBP for each of the candidate standard levels. These standard levels are also referred to as candidate standard levels (CSL).

DOE calculated LCC savings and PBPs relative to the base case equipment that it assigned to the households. As discussed in section 8.2.6, for some households, DOE assigned base case equipment that is more efficient than some of the CSLs. For that reason, the average LCC impacts are not equal to the difference between the LCC of a specific and the LCC of the baseline equipment.

In the subsections below, DOE presents figures showing the distribution of LCCs in the base case for each product class. Also presented below for a specific are figures showing the distribution of LCC impacts and the distribution of PBPs. The figures are presented as frequency charts that show the distribution of LCCs, LCC impacts, and PBPs with their corresponding probability of occurrence. DOE generated the figures for the distributions from a Monte Carlo simulation run based on 10,000 samples.

LCC and PBP calculations were performed 10,000 times on the sample of households established for each residential product. Each LCC and PBP calculation was performed on a single household that was selected from the sample. The selection of a household was based on its weight (i.e., how representative a particular household is of other households in the distribution). Each LCC and PBP calculation also sampled from the probability distributions that DOE developed to characterize many of the inputs to the analysis.

Based on the Monte Carlo simulations that DOE performed, for each standard-level, DOE calculated the share of households with a net LCC benefit, with a net LCC cost, and with no impact. DOE considered a household to receive no impact at a given if DOE assigned it base case equipment that is the same as or has higher efficiency than the CSL. To illustrate the range of LCC and PBP impacts among the sample households, the sections below present figures that provide such information for each product class.

### 8.4.1 Cooktops

#### 8.4.1.1 Base Case LCC Distributions

Figures 8.4.1, 8.4.2, and 8.4.3 show the frequency charts for the base case LCC for the three cooktop product classes. The figures below show the mean LCC of the base case distribution, as well as the full range of LCCs.

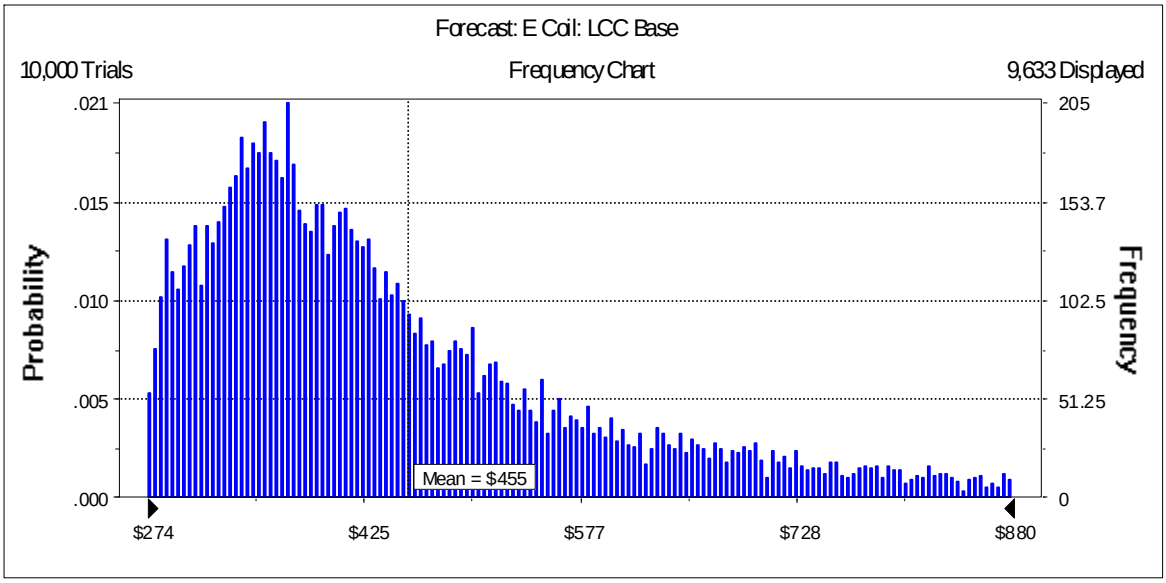


**Figure 8.4.1 Electric Coil Cooktops: Base Case LCC Distribution**

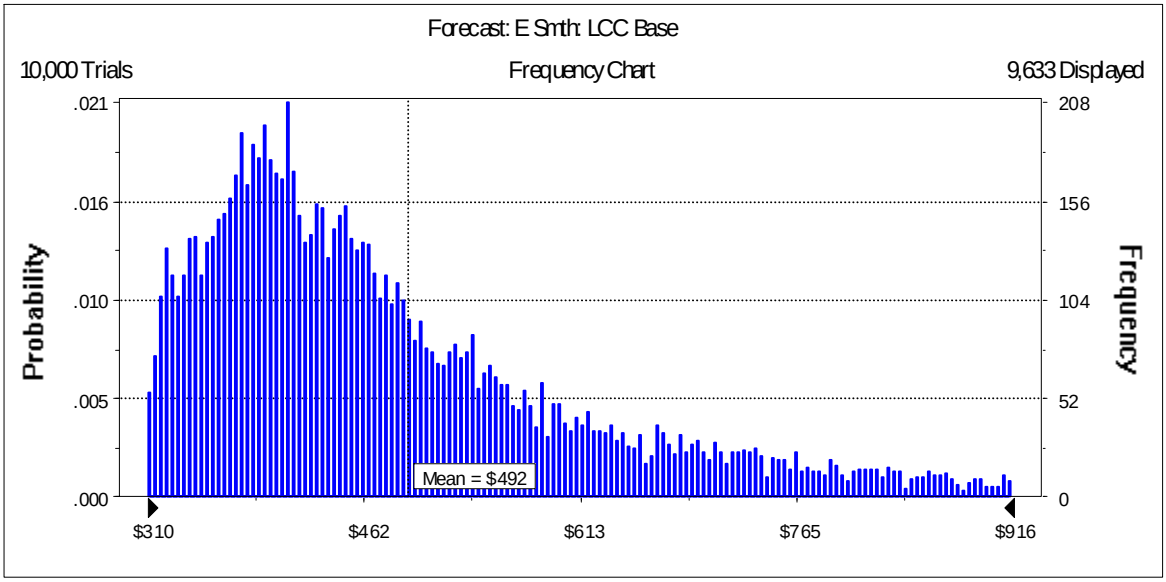


**Figure 8.4.2 Electric Smooth Cooktops: Base Case LCC Distribution**

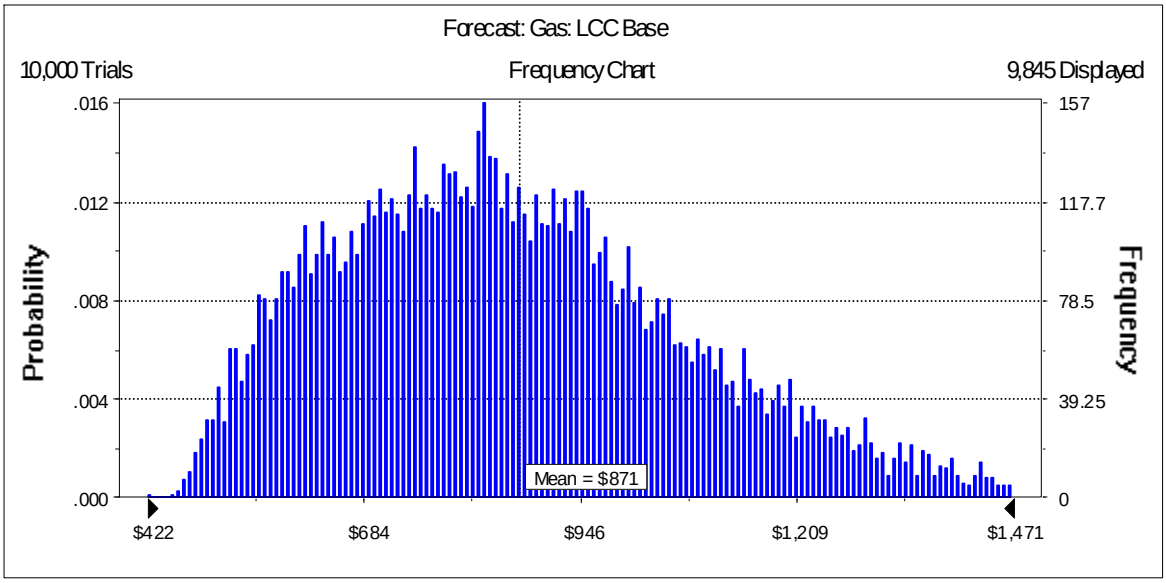


**Figure 8.4.3 Gas Cooktops: Base Case LCC Distribution**

### 8.4.1.2 Standard-Level Distributions of LCC Impacts

Figure 8.4.4 is an example of a frequency chart showing the distribution of LCC differences for the case of CSL 2 for gas cooktops. In the figure, a text box next to a vertical line at that value on the x-axis shows the mean change in LCC (a cost of $8 in the example here). The note, "Certainty is 6.48% from $0 to +Infinity," means that 6.48 percent of households with gas cooktops will either not be impacted or have LCC savings due to the CSL compared to the base case. DOE can generate a frequency chart like the one shown in Figure 8.4.4 for every CSL within each product class.

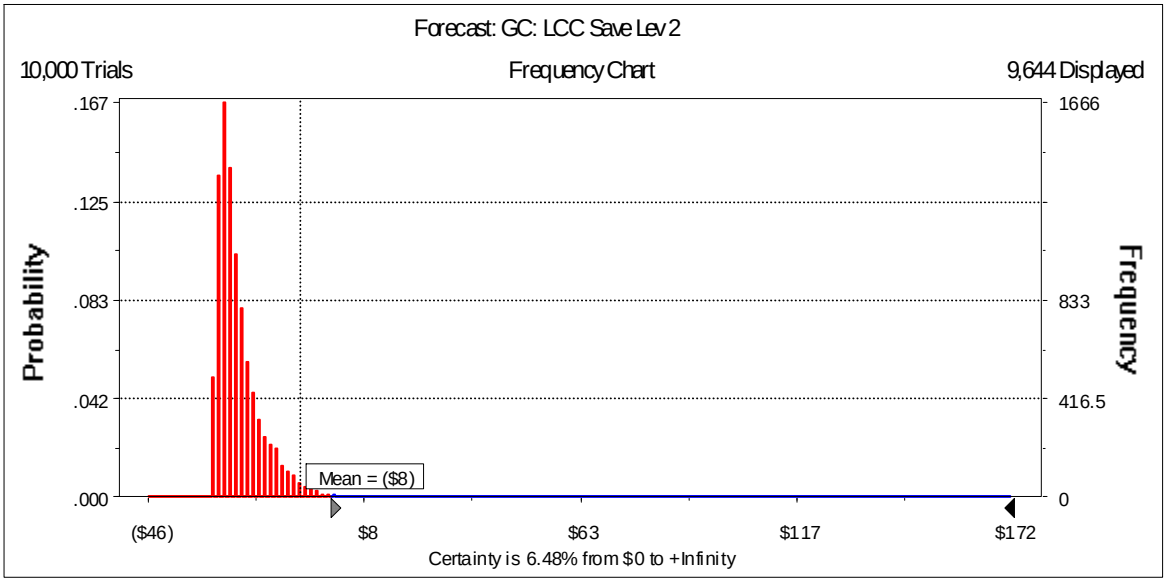


**Figure 8.4.4 Gas Cooktops: Distribution of LCC Impacts for CSL 2**

### 8.4.1.3 Standard-Level PBP Distributions

Figure 8.4.5 is an example of a frequency chart showing the distribution of payback periods for CSL 2 for gas cooktops. The large 'spike' at the PBP value of -1.00 indicates the percentage of households with gas cooktops that do not realize any energy cost savings due to the CSL, i.e., households that rarely or never use their cooktop. DOE can generate a frequency chart like the one shown in Figure 8.4.5 for every CSL within each product class.

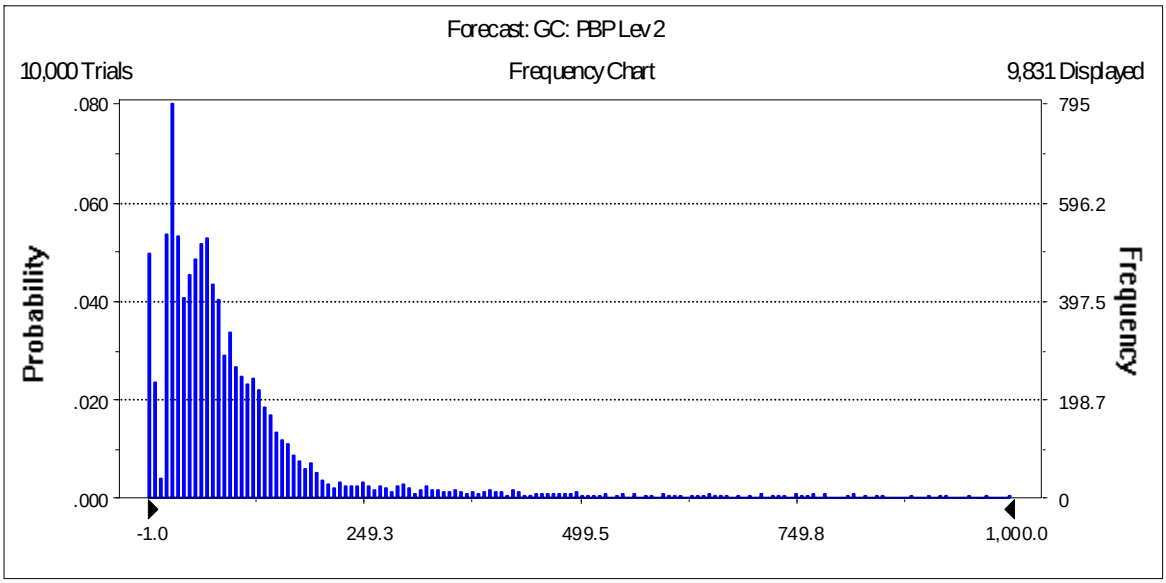


**Figure 8.4.5 Gas Cooktops: Distribution of PBPs for CSL 2**

### 8.4.1.4 LCC and PBP Results

Tables 8.4.1, 8.4.2, and 8.4.3 show the LCC and PBP results for cooktops. For example, in the case of gas cooktops, CSL 1 (pilotless ignition with an efficiency of 0.399 EF) shows an average LCC savings of $15. Note that for CSL 1, over 93 percent of the housing units in 2012 are assumed to have already purchased a gas cooktop with pilotless ignition in the base case and thus have zero savings due to the standard. If one compares the LCC of the baseline at 0.156 EF to the standards case at 0.399 EF, then the average LCC savings are $299. But since the base case includes a significant number of households that are not impacted by the standard, the average savings over all of the households is $15. With regard to the PBPs shown below, DOE determined the median and average values by excluding the percentage of households not impacted by the standard. For example, in the case of CSL 1 for gas cooktops, over 93 percent of the households did not factor into the calculation of the median and average PBP.

**Table 8.4.1 Electric Coil Cooktops: LCC and PBP Results**

| CSL | EF | Life-Cycle Cost | | | Life-Cycle Cost Savings | | | | Payback Period (years) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Average Installed Price | Average Operating Cost | Average LCC | Average Savings | Households with | | | Median | Average |
| | | | | | | Net Cost | No Impact | Net Benefit | | |
| Baseline | 0.737 | $272 | $183 | $455 | - | - | - | - | - | - |
| 1 | 0.769 | $276 | $175 | $451 | $4.3 | 27.1% | 0.0% | 72.9% | 7.2 | 18.0 |

**Table 8.4.2 Electric Smooth Cooktops: LCC and PBP Results**

| CSL | EF | Life-Cycle Cost | | | Life-Cycle Cost Savings | | | | Payback Period (years) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Average Installed Price | Average Operating Cost | Average LCC | Average Savings | Households with | | | Median | Average |
| | | | | | | Net Cost | No Impact | Net Benefit | | |
| Baseline | 0.742 | $309 | $183 | $492 | - | - | - | - | - | - |
| 1 | 0.753 | $550 | $180 | $730 | -$238.2 | 100.0% | 0.0% | 0.0% | 1,498.3 | 3,735.7 |

**Table 8.4.3 Gas Cooktops: LCC and PBP Results**

| CSL | EF | Life-Cycle Cost | | | Life-Cycle Cost Savings | | | | Payback Period (years) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Average Installed Price | Average Operating Cost | Average LCC | Average Savings | Households with | | | Median | Average |
| | | | | | | Net Cost | No Impact | Net Benefit | | |
| Baseline | 0.156 | $310 | $561 | $871 | - | - | - | - | - | - |
| 1 | 0.399 | $332 | $240 | $572 | $15.0 | 0.1% | 93.5% | 6.4% | 4.3 | 3.3 |
| 2 | 0.420 | $361 | $234 | $595 | -$7.9 | 93.5% | 0.0% | 6.5% | 73.0 | 258.3 |

Figures 8.4.6, 8.4.7, and 8.4.8 show the range of LCC savings for the CSLs for electric coil, electric smooth, and gas cooktops, respectively. For each CSL, the top and the bottom of the box indicate the 75$^{th}$ and 25$^{th}$ percentiles, respectively. The bar at the middle of the box indicates the median; 50 percent of the households have LCC savings above this value. The 'whiskers' at the bottom and the top of the box indicate the 5$^{th}$ and 95$^{th}$ percentiles. The small box shows the average LCC savings for each CSL.

Figures 8.4.9, 8.4.10, and 8.4.11 show the range of PBPs for electric coil, electric smooth, and gas cooktops, respectively. In these figures, households which are not impacted by an increase in the standard are not included (this situation applies only for CSL 1 for gas cooktops). In addition, there are a few households where the PBP is an undefined value (i.e., where the lifetime operating expenses of a CSL are greater than the baseline product). This situation occurs when the CSL either has no energy costs savings or its increase in repair and maintenance costs is greater than its lifetime energy cost savings. Undefined PBPs occur for 1.1 percent of households at CSL 1 for electric coil cooktops, 1.1 percent of households at CSL 1 for electric

smooth cooktops, and 0.8 percent of households at CSL 2 for gas cooktops. The few households where the PBP is undefined are not included in Figures 8.4.9, 8.4.10, and 8.4.11.

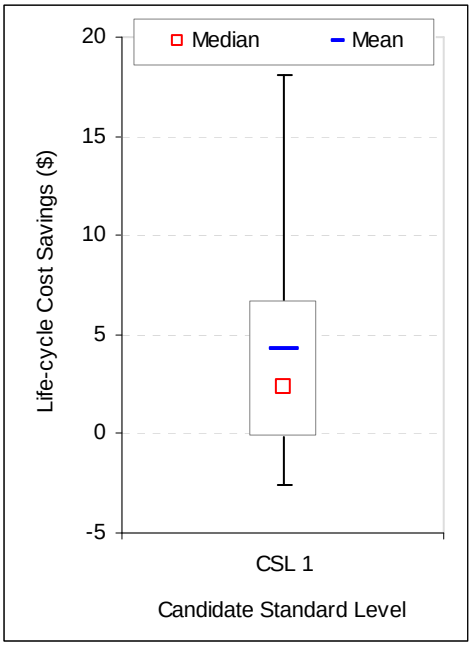


**Figure 8.4.6 Range of LCC Savings for Electric Coil Cooktops**

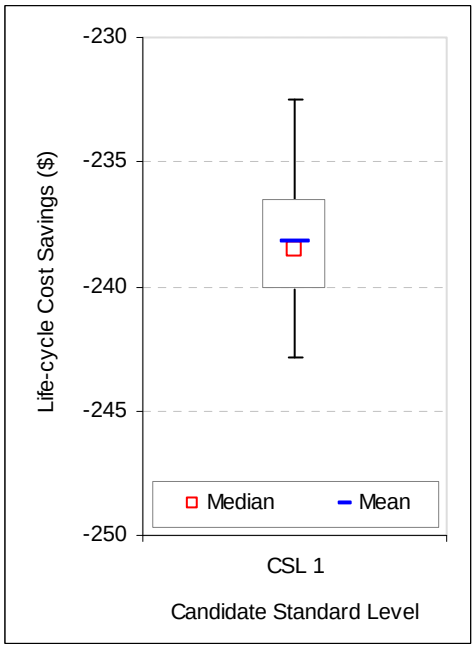


**Figure 8.4.7 Range of LCC Savings for Electric Smooth Cooktops**

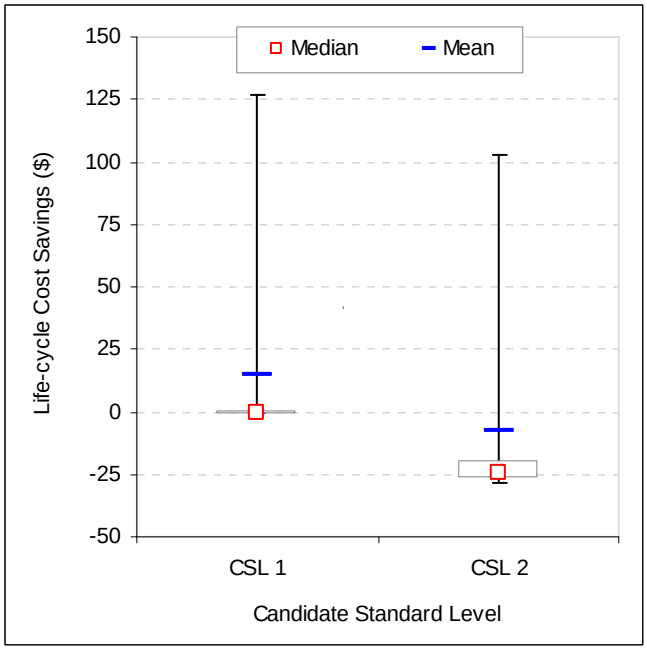


**Figure 8.4.8 Range of LCC Savings for Gas Cooktops**

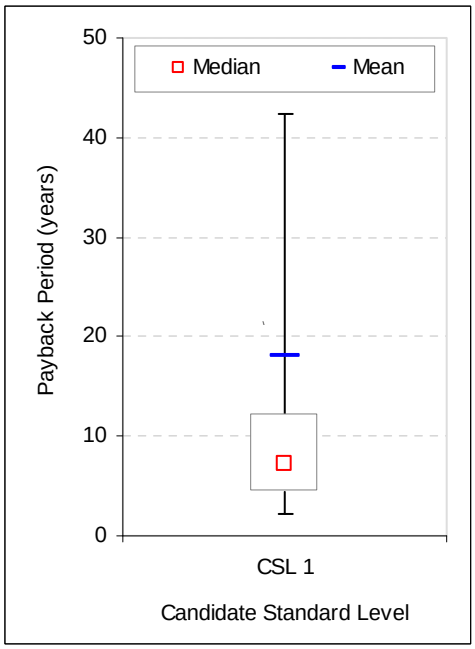


**Figure 8.4.9 Range of Payback Periods for Electric Coil Cooktops**

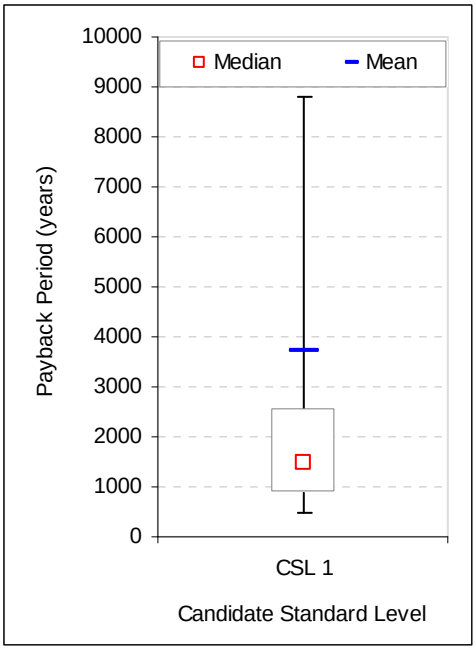


**Figure 8.4.10 Range of Payback Periods for Electric Smooth Cooktops**

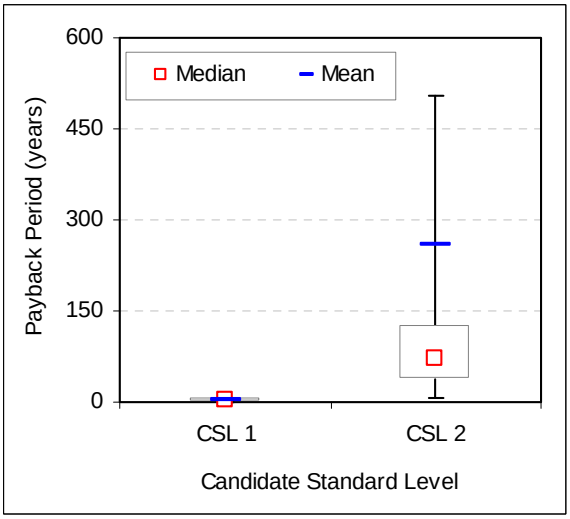


**Figure 8.4.11 Range of Payback Periods for Gas Cooktops**

### 8.4.2 Ovens

#### 8.4.2.1 Base Case LCC Distributions

Figures 8.4.12, 8.4.13, 8.4.14, and 8.4.15 show the frequency charts for the base case LCC for the four oven product classes. The figures below show the mean LCC of the base case distribution as well as the full range of LCCs.

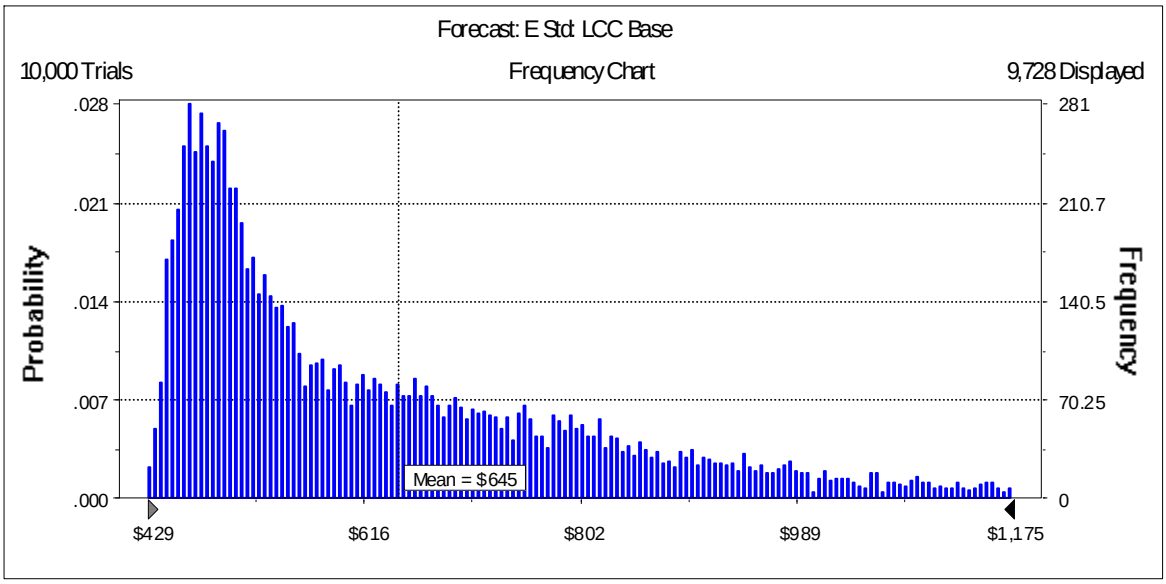


**Figure 8.4.12 Electric Standard Ovens: Base Case LCC Distribution**

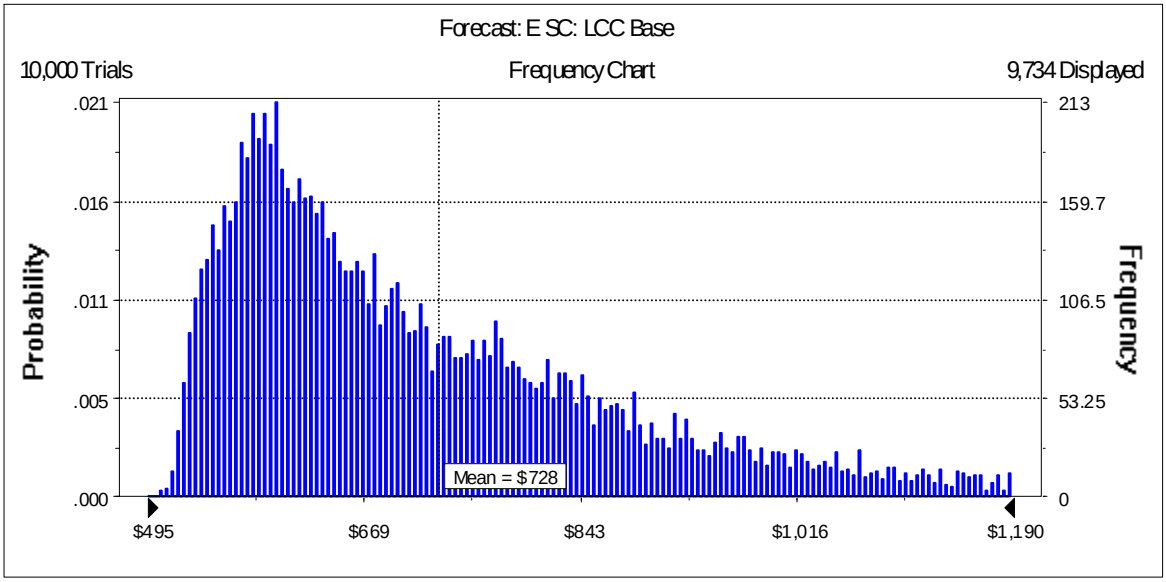


**Figure 8.4.13 Electric Self-Cleaning Ovens: Base Case LCC Distribution**

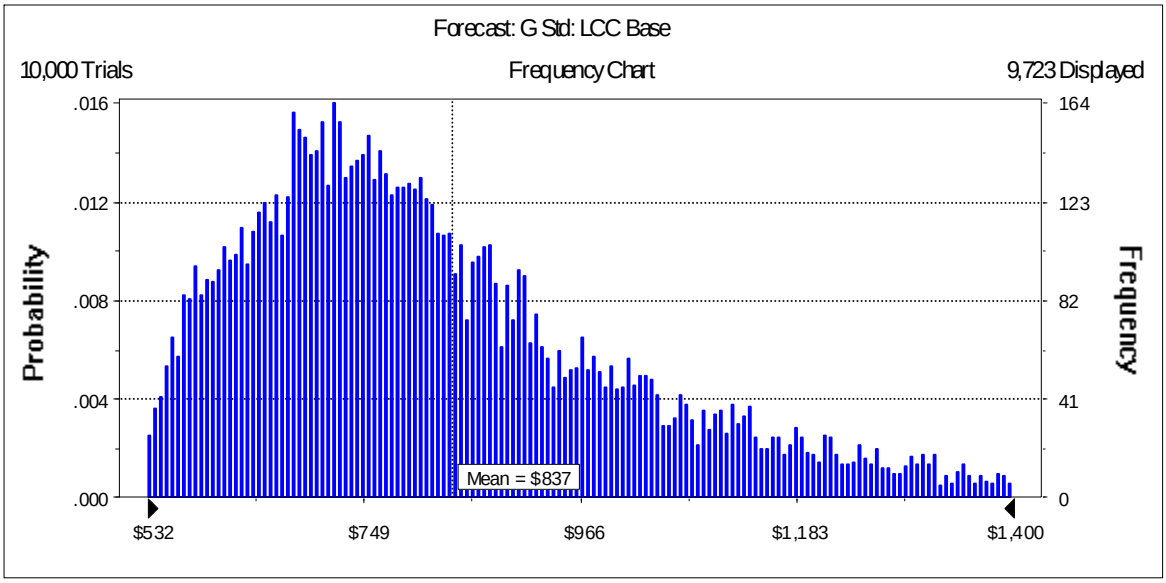


**Figure 8.4.14 Gas Standard Ovens: Base Case LCC Distribution**

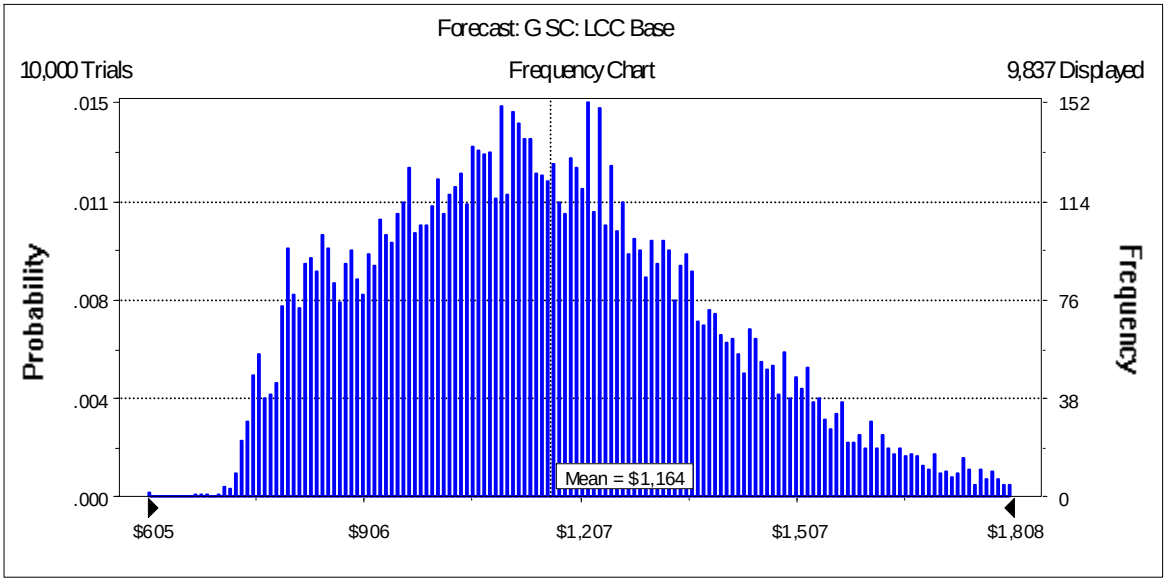


**Figure 8.4.15 Gas Self-Cleaning Ovens: Base Case LCC Distribution**

### 8.4.2.2 Standard-Level Distributions of LCC Impacts

Figure 8.4.16 is an example of a frequency chart showing the distribution of LCC differences for the case of CSL 6 for gas standard ovens. In the figure, a text box next to a vertical line at that value on the x axis shows the mean change in LCC (a cost of $81 in the example here). The note, "Certainty is 6.83% from $0 to +Infinity," means that 6.83 percent of households with gas standard ovens will have LCC savings due to the CSL compared to the base

case. DOE can generate a frequency chart like the one shown in Figure 8.4.16 for every CSL in each of the four oven product classes.

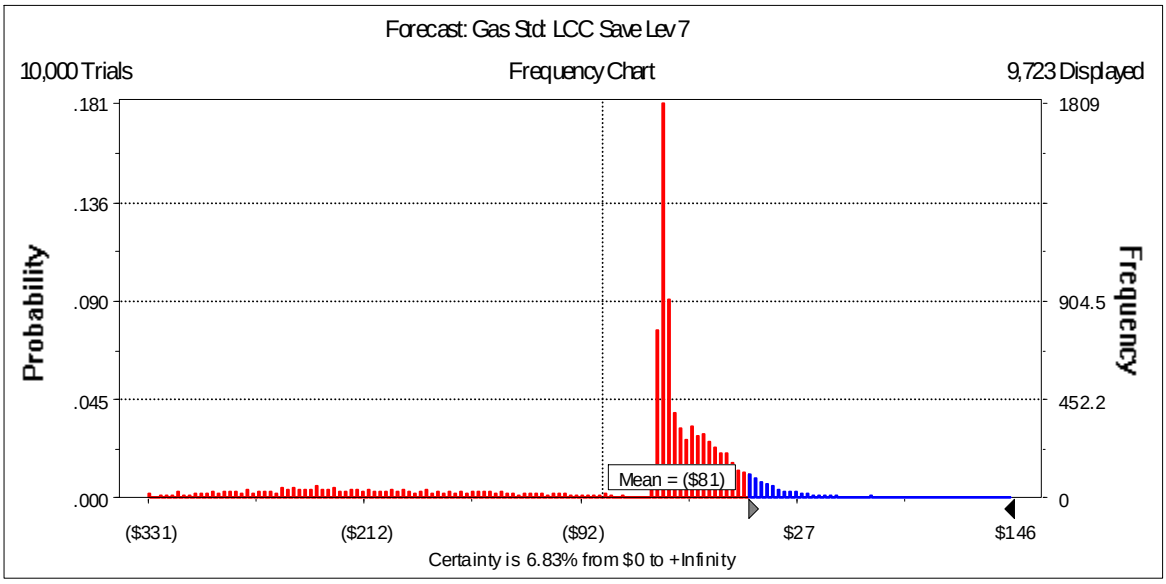


**Figure 8.4.16 Gas Standard Ovens: Distribution of LCC Impacts for CSL 6**

### 8.4.2.3 Standard-Level PBP Distributions

Figure 8.4.17 is an example of a frequency chart showing the distribution of payback periods of CSL 6 for gas standard ovens. DOE can generate a frequency chart like the one shown in Figure 8.4.17 for every CSL in each of the four oven product classes.

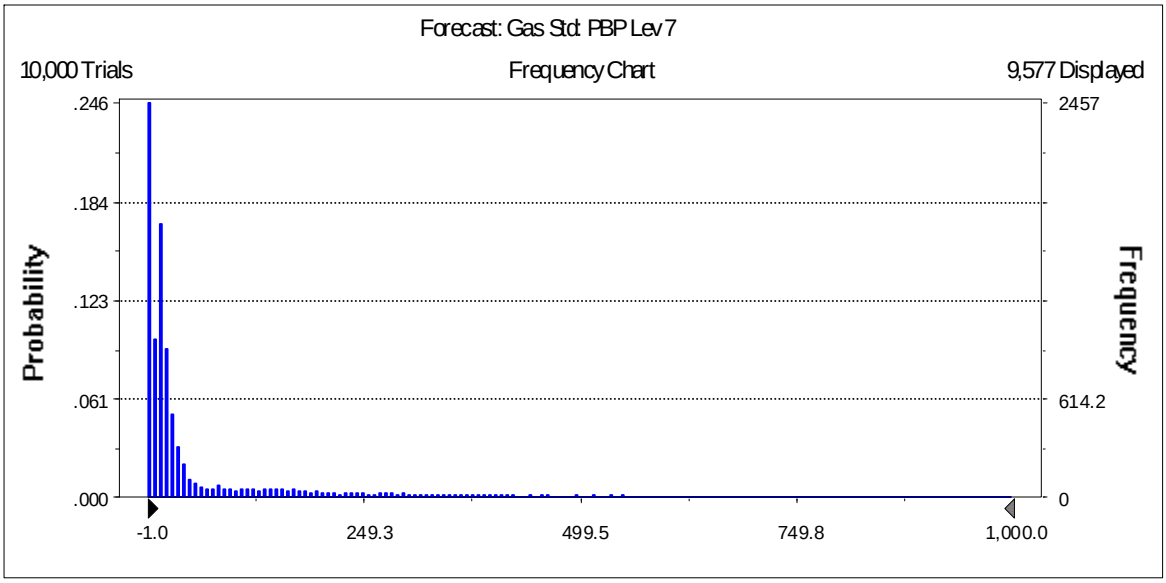


**Figure 8.4.17 Gas Standard Ovens: Distribution of PBPs for CSL 6**

### 8.4.2.4 LCC and PBP Results

Tables 8.4.4, 8.4.5, 8.4.6, and 8.4.7 show the LCC and PBP results for ovens. For example, in the case of gas ovens, CSL 1a (pilotless ignition with an efficiency of 0.0583 EF) shows an average LCC savings of $6. Note that for CSL 1a, 82 percent of the housing units in 2012 are assumed to have already purchased a gas standard oven with pilotless ignition in the base case and thus have zero savings due to the standard. If one compares the LCC of the base case at 0.0298 EF to the standards case at 0.0583 EF, then the average LCC savings are $107. But since the base case includes a significant number of households that are not impacted by the standard, the average savings over all of the households is $9. With regard to the PBPs shown below, DOE determined the median and average values by excluding the percentage of households not impacted by the standard. For example, in the case of CSL 1a for gas standard ovens, 82 percent of the households did not factor into the calculation of the median and average PBP.

## Table 8.4.4 Electric Standard Ovens: LCC and PBP Results

| CSL | EF | Life-Cycle Cost | | | Life-Cycle Cost Savings | | | | Payback Period (years) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Average Installed Price | Average Operating Cost | Average LCC | Average Savings | Households with | | | Median | Average |
| | | | | | | Net Cost | No Impact | Net Benefit | | |
| Baseline | 0.1066 | $414 | $231 | $645 | - | - | - | - | - | - |
| 1 | 0.1113 | $416 | $222 | $638 | $6.5 | 33.8% | 0.0% | 66.2% | 5.3 | 204.6 |
| 2 | 0.1163 | $421 | $213 | $634 | $10.5 | 42.7% | 0.0% | 57.3% | 8.0 | 308.6 |
| 3 | 0.1181 | $426 | $211 | $637 | $8.1 | 50.1% | 0.0% | 49.9% | 12.2 | 466.4 |
| 4 | 0.1206 | $484 | $207 | $690 | -$45.6 | 93.5% | 0.0% | 6.5% | 57.8 | 2,215.9 |
| 5 | 0.1209 | $489 | $206 | $695 | -$50.2 | 94.4% | 0.0% | 5.6% | 60.7 | 2,325.1 |

## Table 8.4.5 Electric Self-Cleaning Ovens: LCC and PBP Results

| CSL | EF | Life-Cycle Cost | | | Life-Cycle Cost Savings | | | | Payback Period (years) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Average Installed Price | Average Operating Cost | Average LCC | Average Savings | Households with | | | Median | Average |
| | | | | | | Net Cost | No Impact | Net Benefit | | |
| Baseline | 0.1099 | $485 | $243 | $728 | - | - | - | - | - | - |
| 1 | 0.1102 | $491 | $243 | $734 | ($89.0) | 72.0% | 0.0% | 28.0% | 174.0 | 926.5 |
| 2 | 0.1123 | $548 | $239 | $787 | ($142.6) | 78.5% | 0.0% | 21.5% | 235.9 | 1,256.2 |

## Table 8.4.6 Gas Standard Ovens: LCC and PBP Results

| CSL | EF | Life-Cycle Cost | | | Life-Cycle Cost Savings | | | | Payback Period (years) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Average Installed Price | Average Operating Cost | Average LCC | Average Savings | Households with | | | Median | Average |
| | | | | | | Net Cost | No Impact | Net Benefit | | |
| Baseline | 0.0298 | $430 | $406 | $837 | - | - | - | - | - | - |
| 1* | 0.0536 | $460 | $500 | $960 | -$31.9 | 17.7% | 82.3% | 0.0% | 10.9 | 8.4 |
| 2 | 0.0566 | $465 | $491 | $956 | -$46.4 | 65.2% | 0.0% | 34.8% | 11.8 | 78.8 |
| 3 | 0.0572 | $467 | $490 | $956 | -$46.6 | 66.4% | 0.0% | 33.6% | 12.2 | 88.0 |
| 4 | 0.0593 | $499 | $486 | $985 | -$75.1 | 92.0% | 0.0% | 8.0% | 23.2 | 358.1 |
| 5 | 0.0596 | $501 | $485 | $987 | -$76.8 | 92.2% | 0.0% | 7.8% | 23.8 | 575.1 |
| 6 | 0.0600 | $507 | $484 | $991 | -$81.0 | 93.2% | 0.0% | 6.8% | 25.3 | 368.4 |
| 1a* | 0.0583 | $464 | $266 | $730 | $9.4 | 5.1% | 82.3% | 12.6% | 9.0 | 7.0 |

* Levels 1 and 1a correspond to designs that are utilized for the same purpose—eliminate the need for a standing pilot—but the technologies for each design are different. Level 1 is a hot surface ignition device while level 1a is a spark ignition device. Level 1a is presented at the end of the table because levels 2 through 6 are derived from level 1.

**Table 8.4.7 Gas Self-Cleaning Ovens: LCC and PBP Results**

| CSL | EF | Life-Cycle Cost | | | Life-Cycle Cost Savings | | | | Payback Period (years) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Average Installed Price | Average Operating Cost | Average LCC | Average Savings | Households with | | | Median | Average |
| | | | | | | Net Cost | No Impact | Net Benefit | | |
| Baseline | 0.0540 | $550 | $614 | $1,164 | - | - | - | - | - | - |
| 1 | 0.0625 | $566 | $595 | $1,161 | $2.9 | 56.1% | 0.0% | 43.9% | 11.0 | 390.6 |
| 2 | 0.0627 | $573 | $594 | $1,167 | -$2.9 | 64.0% | 0.0% | 36.0% | 15.0 | 201.5 |
| 3 | 0.0632 | $574 | $593 | $1,168 | -$3.8 | 65.0% | 0.0% | 35.0% | 15.6 | 461.5 |

Figures 8.4.18, 8.4.19, 8.4.20, and 8.4.21 show the range of LCC savings for the CSLs for electric standard, electric self-cleaning, gas standard, and gas self-cleaning ovens, respectively. For each CSL, the top and the bottom of the box indicate the 75$^{th}$ and 25$^{th}$ percentiles, respectively. The bar at the middle of the box indicates the median; 50 percent of the households have LCC savings above this value. The 'whiskers' at the bottom and the top of the box indicate the 5$^{th}$ and 95$^{th}$ percentiles. The small box shows the average LCC savings for each CSL.

Figures 8.4.22, 8.4.23, 8.4.24, and 8.4.25 show the range of PBPs for electric standard, electric self-cleaning, gas standard, and gas self-cleaning ovens, respectively. In these figures, households which are not impacted by an increase in the standard are not included (this situation applies only for CSLs 1 and 1a for gas standard ovens). In addition, there are a few households where the PBP is an undefined value (i.e., where the lifetime operating expenses of a CSL are greater than the baseline product). This situation occurs when the CSL either has no energy costs savings or its increase in repair and maintenance costs is greater than its lifetime energy cost savings. For gas standard ovens, undefined PBPs occur for 8.1 percent of households at CSL 2, 7.9 percent of households at CSL 3, 24.7 percent of households for CSL 4, 23.7 percent of households for CSL 5, and 22.4 percent of households for CSL 6. For gas self-cleaning ovens, undefined PBPs occur for 16.7 percent of households at CSL 1,16.2 percent of households at CSL 2, and 15.4 percent of households for CSL 3. The households where the PBP is undefined are not included in Figures 8.4.24 and 8.4.25.

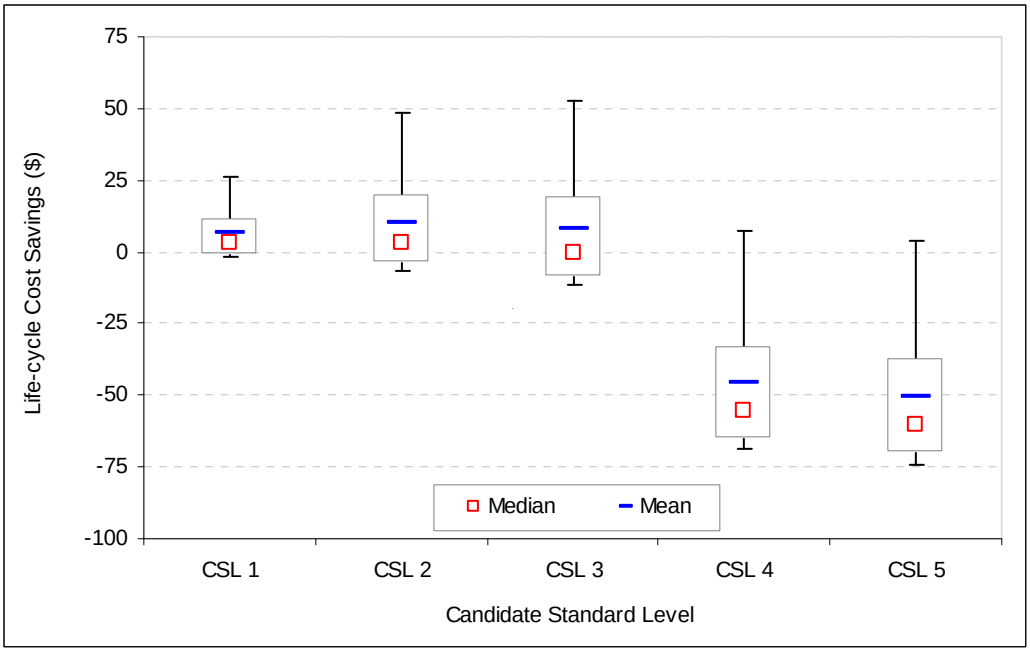


**Figure 8.4.18 Range of LCC Savings for Electric Standard Ovens**

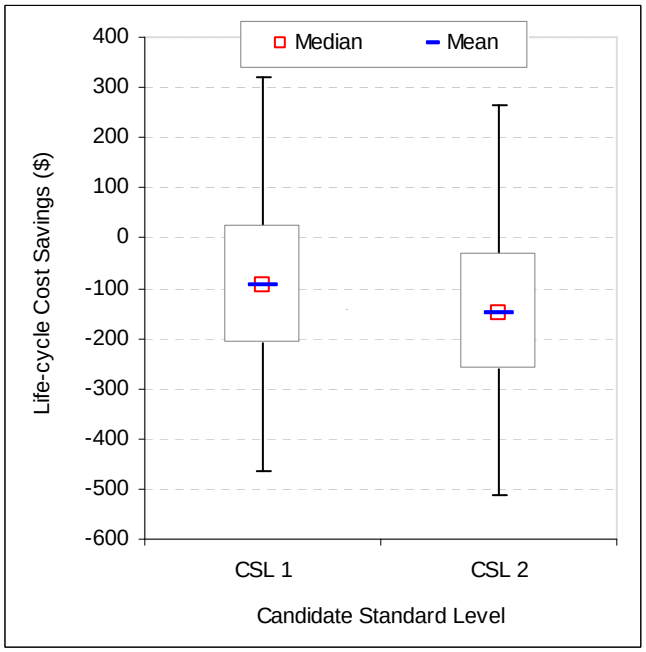


**Figure 8.4.19 Range of LCC Savings for Electric Self-Cleaning Ovens**

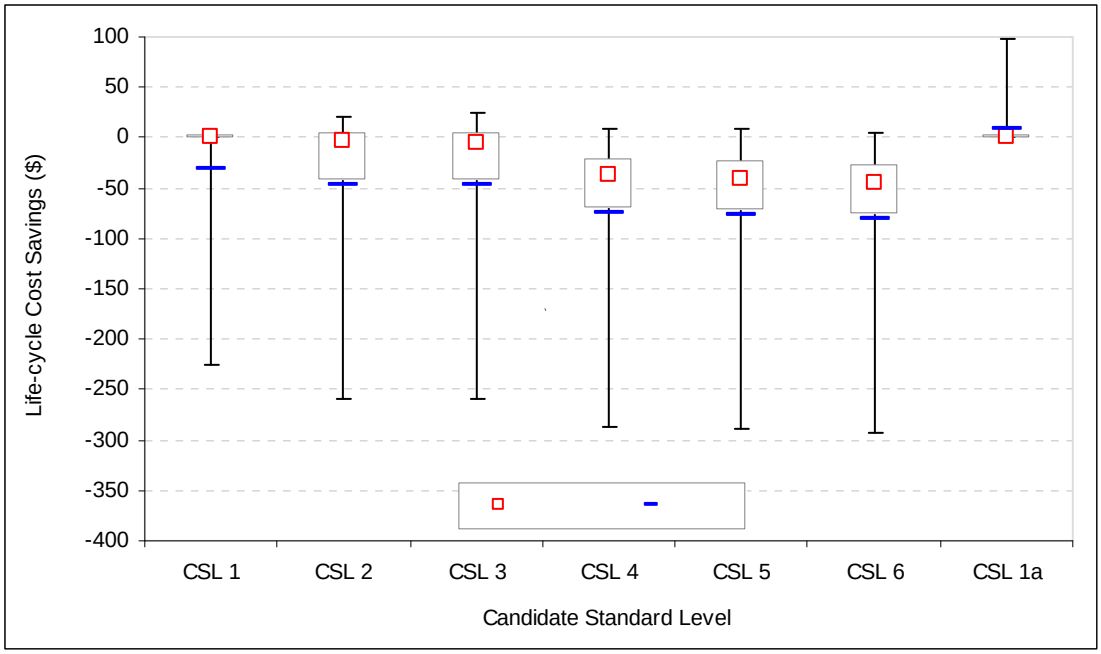


**Figure 8.4.20 Range of LCC Savings for Gas Standard Ovens**

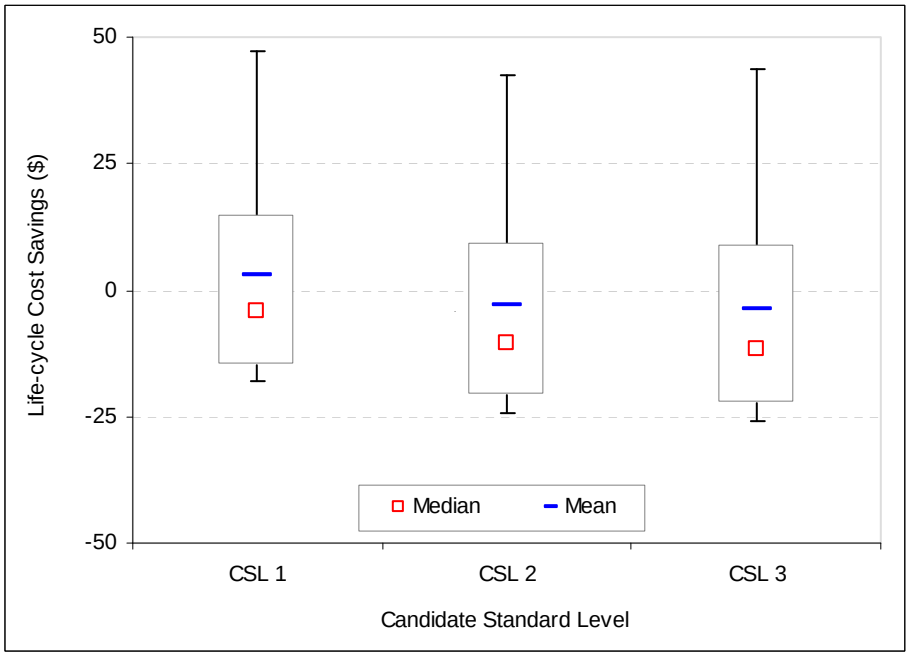


**Figure 8.4.21 Range of LCC Savings for Gas Self-Cleaning Ovens**

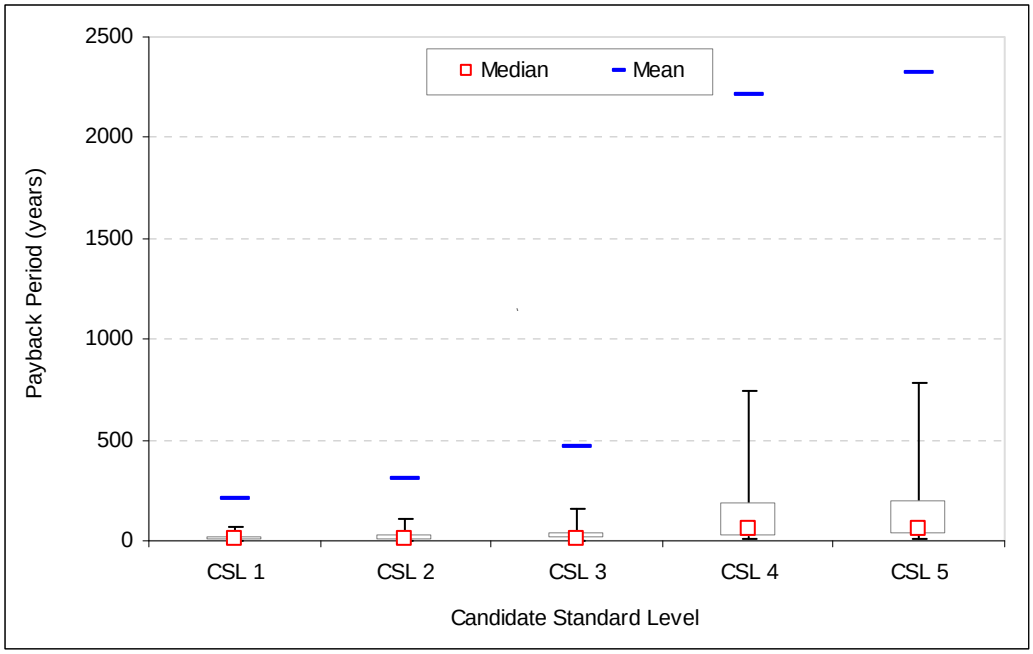


**Figure 8.4.22 Range of Payback Periods for Electric Standard Ovens**

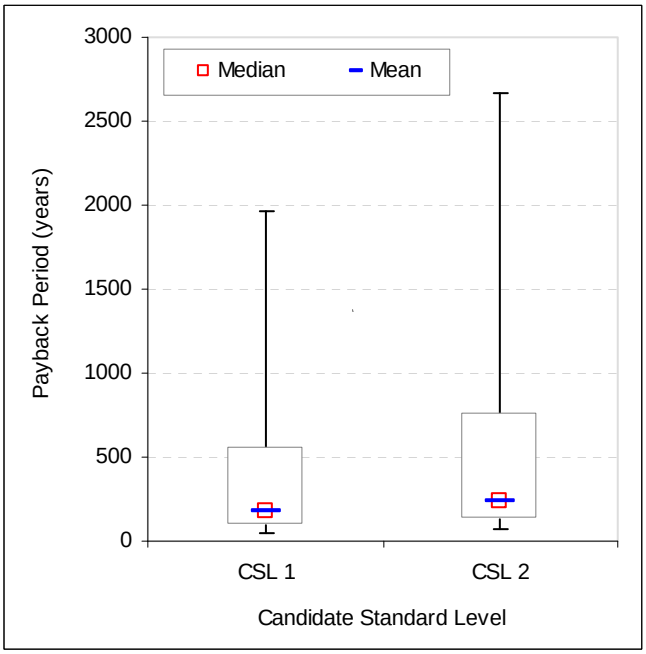


**Figure 8.4.23 Range of Payback Periods for Electric Self-Cleaning Ovens**

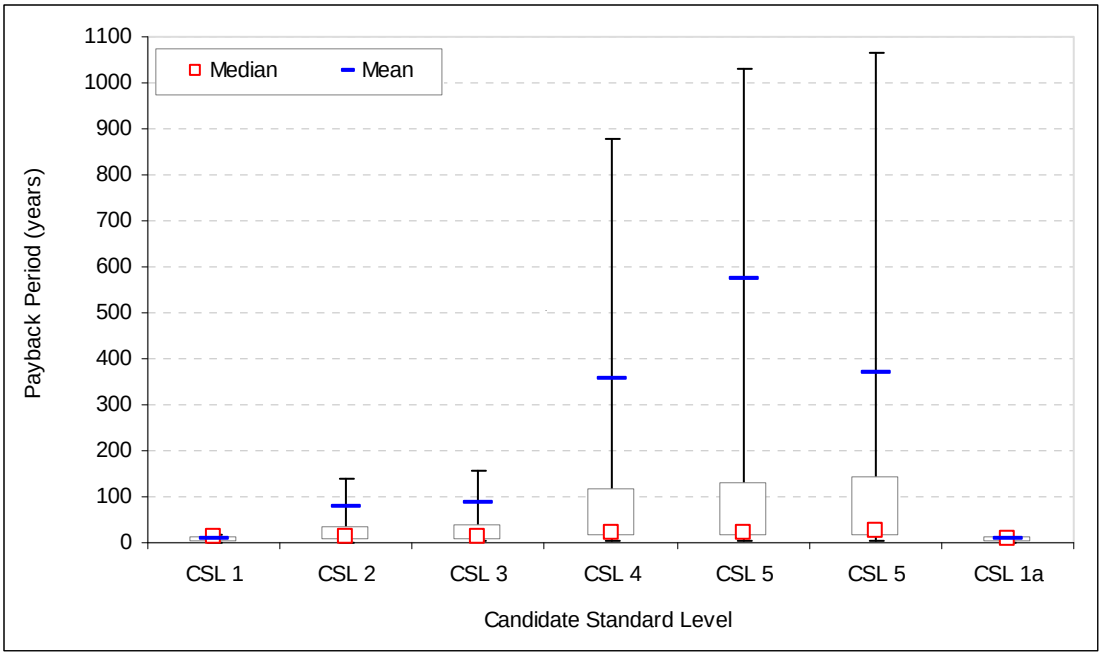


**Figure 8.4.24 Range of Payback Periods for Gas Standard Ovens**

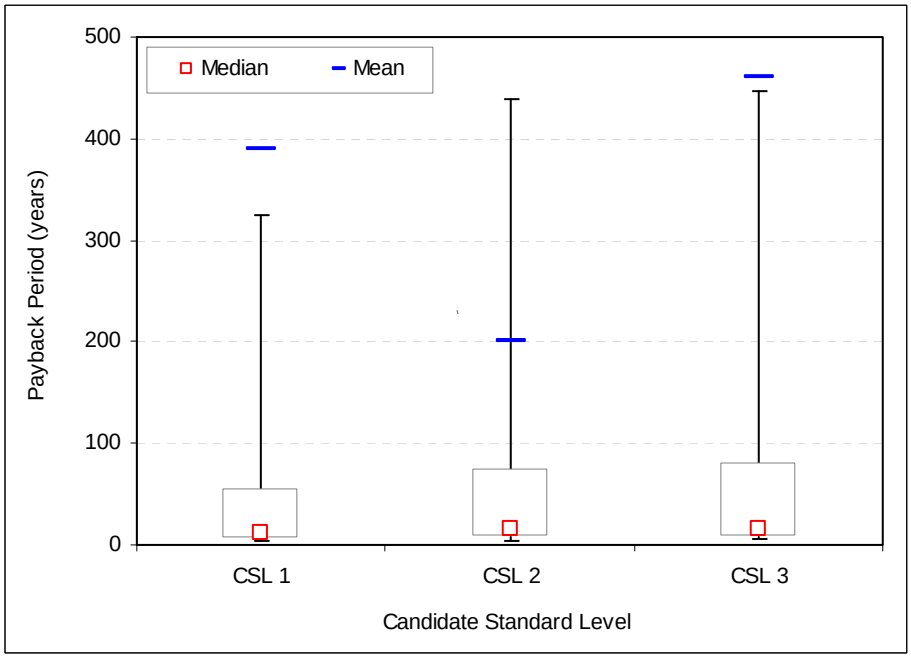


**Figure 8.4.25 Range of Payback Periods for Gas Self-Cleaning Ovens**

### 8.4.3 Microwave Ovens

#### 8.4.3.1 Base Case LCC Distributions

Figure 8.4.26 shows the frequency chart for the base case LCC for microwave ovens. The figure shows the mean LCC of the base case distribution as well as the full range of LCCs.

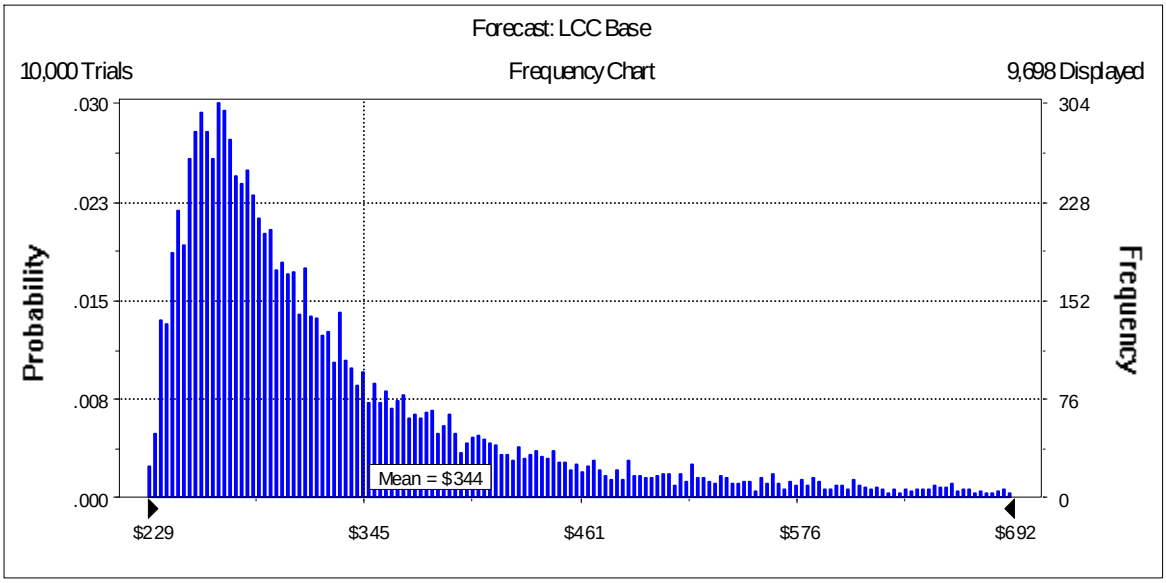


**Figure 8.4.26 Microwave Ovens: Base Case LCC Distribution**

#### 8.4.3.2 Standard-Level Distributions of LCC Impacts

Figure 8.4.27 is an example of a frequency chart showing the distribution of LCC differences for the case of CSL 1. In the figure, a text box next to a vertical line at that value on the x axis shows the mean change in LCC (an increase of $7 in the example here). Note that 9.47 percent of households with microwave ovens will have LCC savings due to the CSL compared to the base case. DOE can generate a frequency chart like the one shown in Figure 8.4.27 for every CSL.

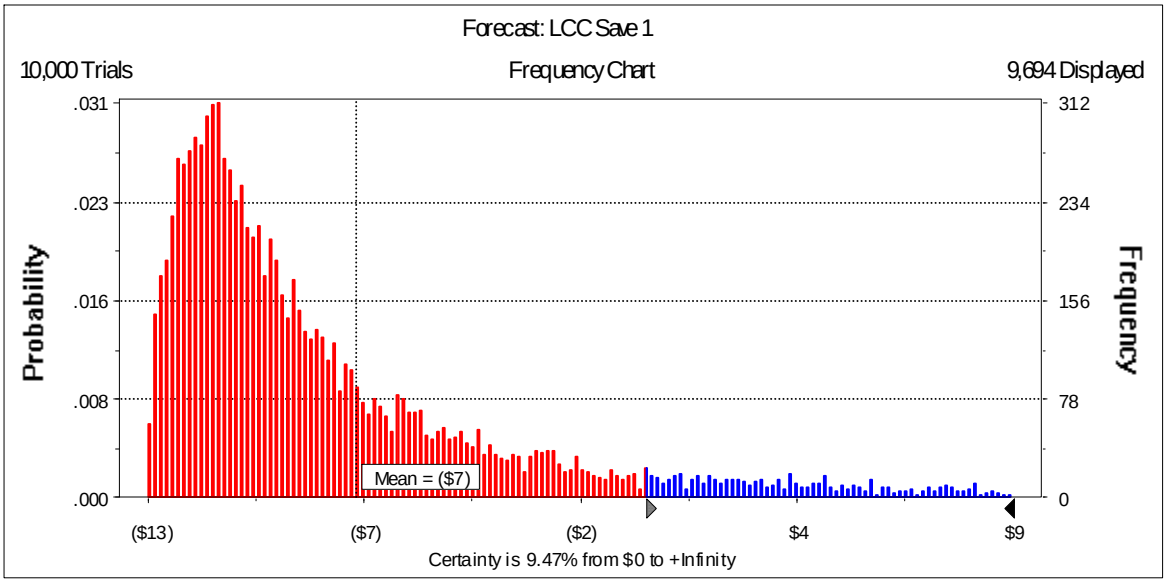


**Figure 8.4.27 Microwave Ovens: Distribution of LCC Impacts for CSL 1**

### 8.4.3.3 Standard-Level PBP Distributions

Figure 8.4.28 is an example of a frequency chart showing the distribution of payback periods of CSL 1. DOE can generate a frequency chart like the one shown in Figure 8.4.28 for every CSL.

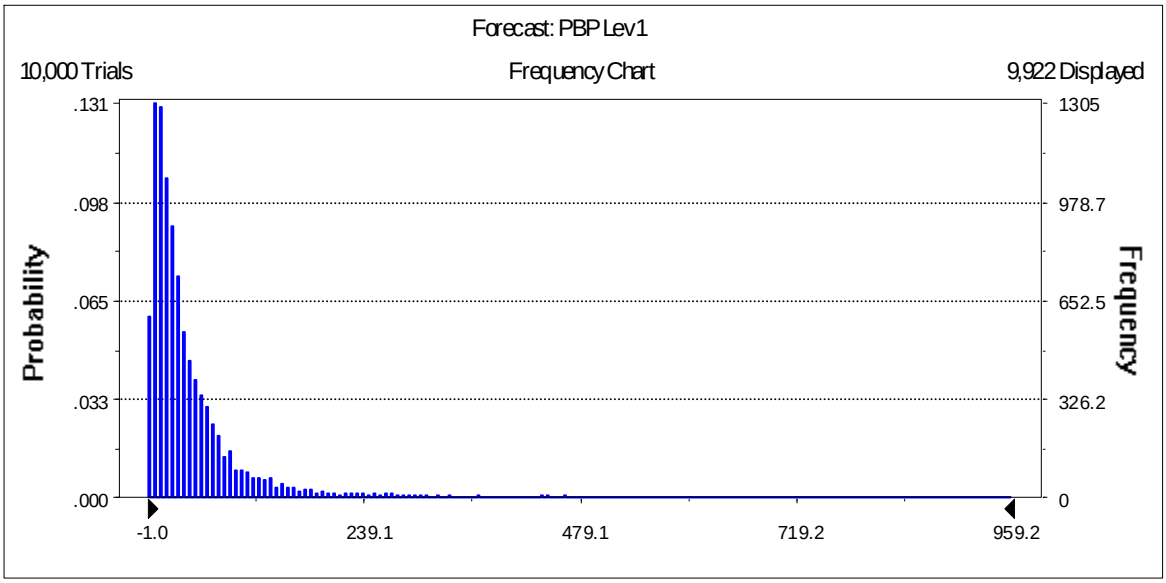


**Figure 8.4.28 Microwave Ovens: Distribution of PBPs for CSL 1**

### 8.4.3.4 LCC and PBP Results

Table 8.4.8 shows the LCC and PBP results for microwave ovens. For example, CSL 1 shows an average LCC increase of $7 and a median PBP of 30 years.

**Table 8.4.8 Microwave Ovens: LCC and PBP Results by Energy Factor Level**

| CSL | EF | Life-Cycle Cost | | | Life-Cycle Cost Savings | | | | Payback Period (years) | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Average Installed Price | Average Operating Cost | Average LCC | Average Savings | Households with | | | Median | Average |
| | | | | | | Net Cost | No Impact | Net Benefit | | |
| Baseline | 0.557 | $220 | $124 | $344 | - | - | - | - | - | - |
| 1 | 0.586 | $232 | $119 | $351 | -$7.4 | 90.6% | 0.0% | 9.4% | 29.9 | 76.0 |
| 2 | 0.588 | $246 | $119 | $364 | -$20.6 | 97.6% | 0.0% | 2.4% | 58.1 | 147.5 |
| 3 | 0.597 | $267 | $117 | $384 | -$40.3 | 99.2% | 0.0% | 0.8% | 82.8 | 210.3 |
| 4 | 0.602 | $294 | $116 | $410 | -$66.4 | 99.8% | 0.0% | 0.2% | 116.6 | 296.1 |

Figure 8.4.29 shows the range of LCC savings for the CSLs for microwave ovens. For each CSL, the top and the bottom of the box indicate the 75$^{th}$ and 25$^{th}$ percentiles, respectively. The bar at the middle of the box indicates the median; 50 percent of the households have LCC savings above this value. The 'whiskers' at the bottom and the top of the box indicate the 5$^{th}$ and 95$^{th}$ percentiles. The small box shows the average LCC savings for each CSL. Figure 8.4.30 shows the range of PBPs for microwave ovens.

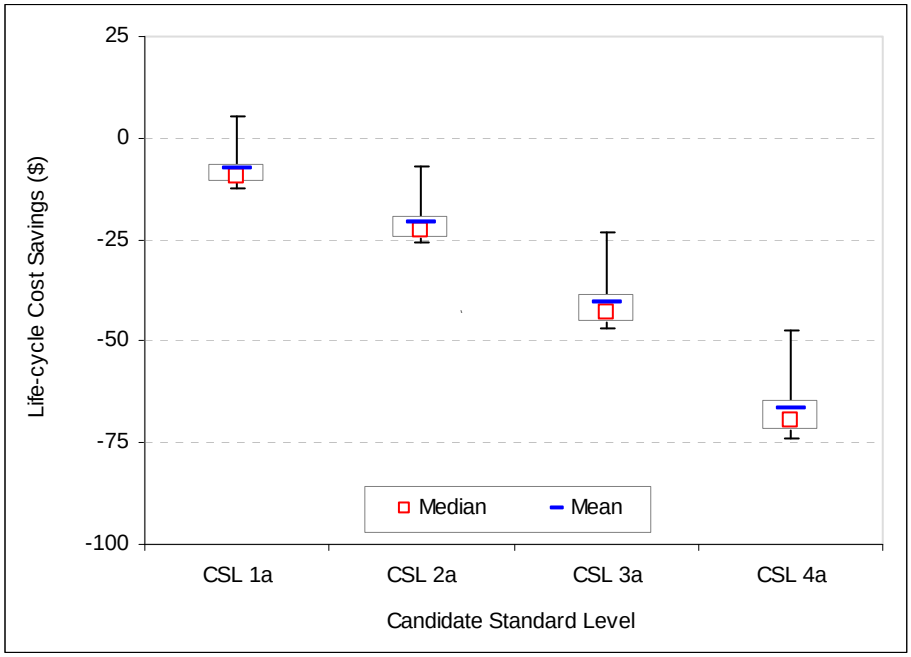


**Figure 8.4.29 Range of LCC Savings for Microwave Oven Energy Factor Levels**

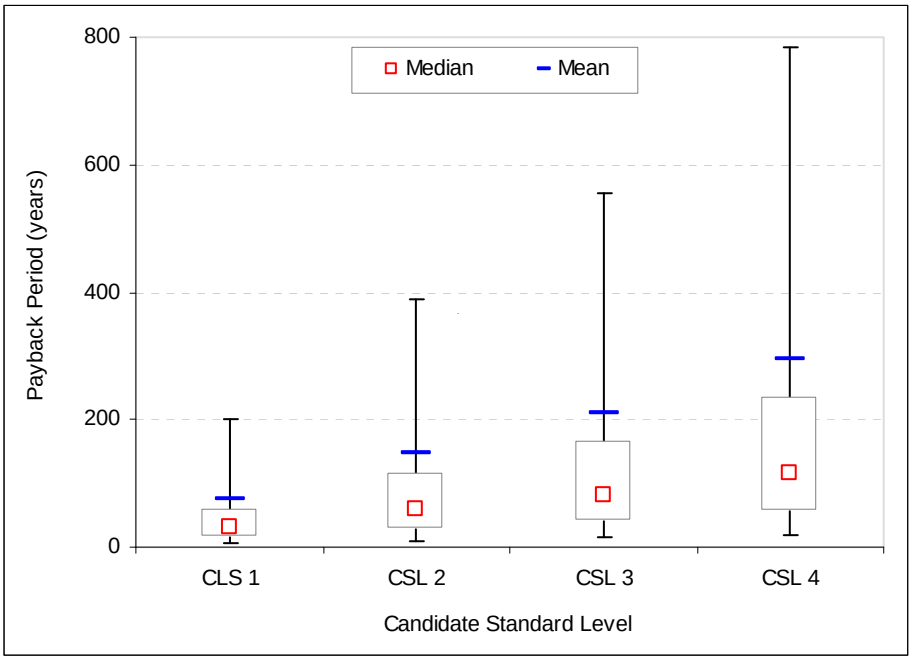


**Figure 8.4.30 Range of Payback Periods for Microwave Oven Energy Factor Levels**

## 8.5 REBUTTABLE PAYBACK PERIOD

DOE presents rebuttable PBPs to provide the legally established rebuttable presumption that an energy efficiency standard is economically justified if the additional product costs attributed to the standard are less than three times the value of the first-year energy cost savings. (42 U.S.C. §6295 (o)(2)(B)(iii))

### 8.5.1 Metric

The basic equation for rebuttable PBP is the same as that shown in section 8.3, Payback Period Inputs. Unlike the analyses described in sections 8.2 and 8.3, however, the rebuttable PBP is not based on the use of household samples and probability distributions. Rather than distributions, the rebuttable PBP is based on discrete single-point values. For example, while DOE uses a probability distribution of regional energy prices in the distributional payback period analysis, it uses only the national average energy price from the probability distribution to determine the rebuttable PBP.

Other than the use of single-point values, the most notable difference between the distribution PBP and the rebuttable PBP is the latter's reliance on the DOE test procedure to

determine a product's annual energy consumption. For the products being considered under this standards rulemaking, the following sections identify the differences, if any, between the annual energy consumption determined for the distribution PBP and the rebuttable PBP.

For the rebuttable PBP, DOE determined the annual energy consumption of cooking products based on the annual useful cooking energy output values in the DOE test procedure.[27] On average, the annual useful cooking energy output values that DOE used to determine the distribution PBPs are lower than the values in the DOE test procedure. Because the annual energy consumption is determined by dividing the annual useful energy cooking output value by the cooking product's energy factor, the annual energy consumption values that DOE calculated for the determination of distribution PBP are on average lower than the annual energy consumption values DOE used to determine the rebuttable PBP.[c] The higher the annual energy consumption value, the greater the potential of energy efficiency improvements to save energy. Thus, the rebuttable PBPs for cooking products will be shorter than the distribution PBPs. Table 8.5.1 shows the difference in the annual useful cooking energy output values that DOE used to calculate the rebuttable PBP and distribution PBP.

**Table 8.5.1 Annual Useful Cooking Energy Output Values: Comparison of Values Used for the Determination of Rebuttable PBP and Distribution PBP**

| | **Rebuttable PBP*** | | **Distribution PBP**** | |
|---|---|---|---|---|
| | **Electric** | **Gas** | **Electric** | **Gas** |
| **Product Type** | *kWh/yr* | *MMBtu/yr* | *kWh/yr* | *MMBtu/yr* |
| Cooktops | 173.1 | 527.6 | 94.8 | 289.1 |
| Ovens | 29.3 | 88.8 | 16.1 | 48.7 |
| Microwave Ovens | 79.8 | | 73.0 | |

* Based on DOE test procedure.

** Based on more recent field energy consumption data (see Chapter 6, section 6.2).

### 8.5.2 Inputs

Inputs for the rebuttable PBP differ from the distribution PBP in that the calculation uses discrete values, rather than distributions, for inputs. Note that for the calculation of distribution PBP, because inputs for the determination of total installed cost were based on single-point values, only the variability and/or uncertainty in the inputs for determining operating cost contributed to variability in the distribution PBPs. The following summarizes the single-point values that DOE used in the determination of the rebuttable PBP.

[c] As described in section 6.2 of Chapter 6, Energy Use Determination, DOE actually used a range of annual energy use values in its LCC and PBP analysis. The range or variability of annual energy use values is inherent to the household sample that DOE used to conduct the analysis. Although some households in the sample have an annual energy use value that is higher than what is calculated from the DOE test procedure, on average, the annual energy consumption determined from the household sample was lower than the annual energy consumption determined from the DOE test procedure.

- Manufacturing costs, markups, sales taxes, and installation costs were all based on the single-point values used in the distributional LCC and PBP analysis.

- As described in section 8.5.1, annual energy consumption is based on the DOE test procedure.

- Energy prices are based on national average values for the year that new standards are assumed to take effect.

- An average discount rate or lifetime is not required in the rebuttable PBP calculation.

- The effective date of the standard is assumed to be 2012.

### 8.5.3 Results

DOE calculated rebuttable PBPs for each CSL relative to the distribution of product efficiencies assumed for the base case (refer back to section 8.2.6 for more details on the base case efficiency distributions for each product). In other words, DOE did not determine the rebuttable PBP relative to the baseline efficiency level, but relative to the current distribution of product efficiencies DOE determined for the base case (i.e., the case without new standards). The following sections present the results for the sets of products being analyzed for this standards rulemaking.

#### 8.5.3.1 Cooktops

Table 8.5.2 presents the rebuttable PBPs for all three classes of cooktops.

**Table 8.5.2 Cooktops: Rebuttable Payback Periods**

| Electric Coil | | | Electric Smooth | | | Gas | | |
|---|---|---|---|---|---|---|---|---|
| **CSL** | **EF** | **PBP** *years* | **CSL** | **EF** | **PBP** *years* | **CSL** | **EF** | **PBP** *years* |
| Baseline | 0.737 | - | Baseline | 0.742 | - | Baseline | 0.156 | - |
| 1 | 0.769 | 3.2 | 1 | 0.753 | 664 | 1 | 0.399 | 3.1 |
| | | | | | | 2 | 0.420 | 13.0 |

#### 8.5.3.2 Ovens

Table 8.5.3 presents the rebuttable PBPs for all four classes of ovens.

**Table 8.5.3 Ovens: Rebuttable Payback Periods**

| Electric Standard | | | Electric Self-Clean | | | Gas Standard | | | Gas Self-Clean | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **CSL** | **EF** | **PBP** *years* | **CSL** | **EF** | **PBP** *years* | **CSL** | **EF** | **PBP** *years* | **CSL** | **EF** | **PBP** *years* |
| Baseline | 0.1066 | - | Baseline | 0.1099 | - | Baseline | 0.0298 | - | Baseline | 0.0540 | - |
| 1 | 0.1113 | 1.9 | 1 | 0.1102 | 77.0 | 1* | 0.0536 | 10.3 | 1 | 0.0625 | 6.1 |
| 2 | 0.1163 | 2.9 | 2 | 0.1123 | 104.3 | 2 | 0.0566 | 8.9 | 2 | 0.0627 | 8.2 |
| 3 | 0.1181 | 4.4 | | | | 3 | 0.0572 | 8.8 | 3 | 0.0632 | 8.5 |
| 4 | 0.1206 | 20.8 | | | | 4 | 0.0593 | 18.5 | | | |
| 5 | 0.1209 | 21.9 | | | | 5 | 0.0596 | 18.8 | | | |
| | | | | | | 6 | 0.0600 | 19.6 | | | |
| | | | | | | 1a* | 0.0583 | 6.9 | | | |

* Levels 1 and 1a correspond to designs that are utilized for the same purpose—eliminate the need for a standing pilot—but the technologies for each design are different. Level 1 is a hot surface ignition device while level 1a is a spark ignition device.

#### 8.5.3.3 Microwave Ovens

Table 8.5.4 present the rebuttable PBPs for microwave ovens.

**Table 8.5.4 Microwave Ovens: Rebuttable Payback Periods for Energy Factor Levels**

| CSL | EF | PBP<br>*years* |
|---|---|---|
| Baseline | 0.557 | - |
| 1 | 0.586 | 16.4 |
| 2 | 0.588 | 31.9 |
| 3 | 0.597 | 45.4 |
| 4 | 0.602 | 64.0 |

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